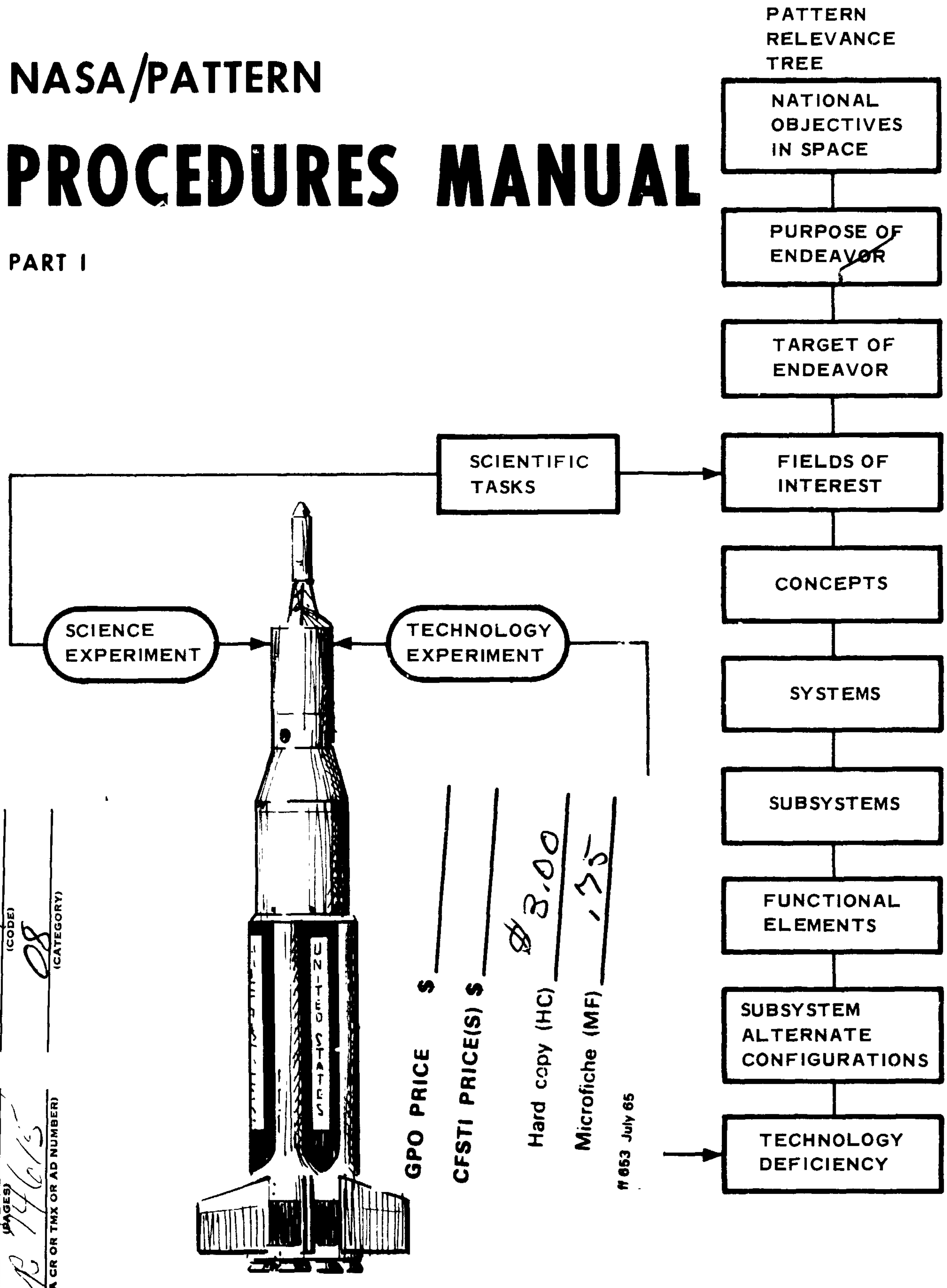
NASA/PATTERN

PROCEDURES MANUAL

PART I



SATURN I-B

APOLLO PAYLOAD EVALUATION

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NASA PATTERN

PROCEDURES MANUAL

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Section 1

INTRODUCTION

This document serves as an instruction manual on the use of Honeywell's PATTERN technique to determine the relative value of candidate space experiments. In this application, PATTERN addresses itself to the problem of experiment payload selection, providing a measure of experiment worth through determination of its relevance to national space objectives.

The document presents an introduction to, and general familiarization with PATTERN in the text, and then provides working level details in the series of appendixes. The main body text defines PATTERN and its composition, discusses what was done under the contract, and outlines special features of PATTERN. The appendixes discuss application of the technique, show the appropriate mathematical relations, and detail the computer program.

Briefly, the work accomplished under this contract included the full application of the Honeywell-developed PATTERN technique to Marshall Space Flight Center Experiment Planning by:

- The construction of a ten-level Space Relevance Tree based on detailed analysis of future space missions, candidate programs, systems, subsystem requirements, alternate subsystem configurations, and their associated technology deficiencies.

- The formulation of suitable decision criteria for making quantitative judgements at each level of the PATTERN Relevance Tree.

- The preparation and documentation of the necessary space science, space application, future program and supporting technology requirement data to assist in making quantitative judgements at each level of the Relevance Tree. This material is contained in the three-volume Relevance Guide delivered under the contract.

- The assignment and recording for NASA review of a complete set of numerical values for all levels of the Relevance Tree based on both the technical data generated under the study and the procedures presented in this document. These value judgements were made by a group of experienced personnel meeting together in order to assure maximum exchange of experience and data content in the documented material.

- The ranking of a sample list of approximately 60 candidate space experiments as a demonstration of the usefulness of the PATTERN technique.

- The programming, computing, and storage of the Relevance Tree, decision criteria, experiment data, and numerical judgements in the electronic computer at the Marshall Space Flight Center. Certain output data under this contract was therefore supplied directly from the Computation Laboratory at MSFC.

- The documenting of all factors, definitions, and important data used in assigning value judgements, in the Relevance Guide volumes and in this Procedures Manual.

- The establishment of a convenient method to review and evaluate the factors considered at each level, and for the addition or correction of the stored data. Also provided are procedures for reviewing and changing judgements and output parameters based on superior judgement, new data or changing events.

Section 2

PATTERN

2.1 DEVELOPMENT OF PATTERN

PATTERN is an acronym for Planning Assistance Through Technical Evaluation of Relevance Numbers. Honeywell developed PATTERN as a quantitative aid in making corporate decisions about long-range technical planning. For Honeywell use, it measured the relevance of R&D efforts to national objectives. However, the technique has broad application in many decision areas, the most useful in areas involving decisions composed of a series of complex factors. It provides real assistance both in the assimilation and the analysis of large bodies of data, as well as providing ready access to the original data for its simple updating. In particular, original PATTERN efforts addressed themselves to two difficult factors the technical planner weighs in making decisions: assessment of the technological capabilities of the country and the needs facing the government in ensuring national security. PATTERN's output is a ranking of the elements involved in making such assessments, made by highly qualified personnel on selected criteria.

2.2 NASA PATTERN

The NASA PATTERN study evolved from a technical proposal entitled, "A Methodology for Planning Passenger Payloads for Saturn I-B Using the PATTERN Technique." The NASA project devolved from the additional Saturn I-B boost capability which allows the incorporation of passenger payloads on presently programmed flights. Such payloads enhance the mission value of the Saturn system, and if properly reflected against Marshall Space Flight Center and national space objectives, would contribute directly to meeting both scientific and technological needs of future MSFC and national space programs.

The selection of payloads necessarily involves many complex factors requiring utilization of both experienced personnel and sophisticated techniques to provide decision data consistent with long-range goals. The PATTERN application was to provide techniques for use as one factor in the evaluation of the importance of payloads and in the assignment of priorities for implementation. In particular, PATTERN was designed to assist the MSFC Experiment Coordination Office in the selection of candidate secondary payloads. In summary, the technique would:

- Devise a technique for aiding complex payload selection,
- Rank payloads according to long-range goals, and
- Provide a method for its continuing use at MSFC.

The primary objective of the contract was to adapt to the NASA problem. Examination of NASA long-range goals along with appropriate decomposition of selected variables was developed in the tree structure which PATTERN uses as its logical ordering device. Full discussion of this phase is found in paragraph 2.3.1, Relevance Tree.

Experiments were provided by the NASA contract technical monitor. The sample list included sixty experiments which were ranked as a demonstration of the technique. These experiments were ranked by comparing the relative contribution made by completing the experiment with the contribution made by completing identified space science tasks or the supporting technological deficiencies.

Experiments were divided into two groups:

Space Science/Utilization - Those experiments that directly explore new areas of science or provide new utility of the space environment.

Supporting Technology - Those experiments that directly identify or aid solution of advanced technological problems associated with future systems development.

Paragraph 2.3.5 provides a detailed discussion of the techniques used in experiment ranking.

2.3 PATTERN TECHNIQUE

2.3.1 Relevance Tree

The PATTERN technique involves two fundamental problems in decision making:

- Large numbers of complex, interrelated factors,
- Discovery of inexplicit relationships among factors.

PATTERN decomposes composite variables into their parts for simple decision-making and then relates the parts to one another. A tree structure summarizes the interrelationship of the elements, the upper part of the tree dealing with broad categorizations of goals and objectives, and the lower with the details of the means of achieving the goals. The decomposition is necessary because of the difficulty of simultaneous accommodation by the human mind of more than a few (somewhat less than twenty) factors. Complex decisions require accommodation of several hundred factors and interactions making value judgements difficult. A large quantity of data is generated from the factors and interactions along the tree. PATTERN, then, is the decomposition of variables into conceptually, manageable bits and the manipulation and organization of the bits to preserve the validity of inherent, yet inexplicit, values.

The initial task is identification of the variables of interest. This phase provides a broad base of information on the topic from which significant elements are chosen. PATTERN begins with the overall NASA space objectives, their definition and interaction. PATTERN solves the difficulty of defining often indefinite goals by recognizing that objectives and goals may be categorized without specific definition of any single goal. For NASA, the first categorization of objectives was that of Space Science and Space Utilization. This categorization process continues to the lowermost level which for NASA was the Technological Deficiency level. Here specific areas of development were detailed.

2.3.1.1 Tree Elements. Tree elements represent the components or the selected variables. The tree follows the normal branching system with each branch point (node) requiring a relevance determination. All elements connected to a node are considered together for the relevance determination, making the numerical judgement one of determining the relative value to the node of improvement of present capability in each of the defined elements.

Tree elements are derived from an identification and assessment of requirements by a qualified team of personnel. The NASA PATTERN tree was based on space requirements and was composed of ten levels as illustrated in Figure 2-1.

Definition of each level and the elements that compose it is made in the Relevance Guide. The following represents a capsule description of the levels as identified in Figure 2-1:

- Level zero is the summary or total objective level of the tree. It has a relevance value of 1.00 and represents the totality of NASA space objectives.

- Level one identified the two principal divisions of space objectives, Space Science and Space Utilization.

- Level two identifies Targets of Endeavor for the two branches of the tree. For example, Space Science targets of endeavor are Mars, Moon, Comets, Sun, etc., while Space Utilization targets are the practical utilization of a radiation environment, vacuum environment, gravity environments, etc.

- Level three identifies Fields of Interest for each of the targets. Lunar fields of interest, for example, are atmosphere and ionosphere, biology, composition, magnetosphere and radiation belts, and geodesy and mapping. Vacuum environment fields of interest are biology, manufacturing, transportation, and R&D lab.

- Level four identifies Tasks requiring accomplishment in each of the fields of interest. Included under the lunar composition field of interest are such scientific tasks as IR surface mapping, study of gross physical surface characteristics, and study of lunar outgassing.

These four levels comprise the "upper half" of the tree and represent the categorization of interest elements.

- Level five identifies concepts or missions which, while not presently specifically programmed, represent a feasible sampling of possibilities available to 1985. Each concept heads a tree of its own which outlines the specific configuration and problems associated with it. Each concept is applied to each field of interest (level three) to determine its relative contribution with respect to other concepts for performing the scientific or utilization field of interest. Only connections which could make a direct contribution to the field of interest are considered. For example, the meteorological satellites would have no direct contribution in determining Mars composition and would not be considered for that field of interest.

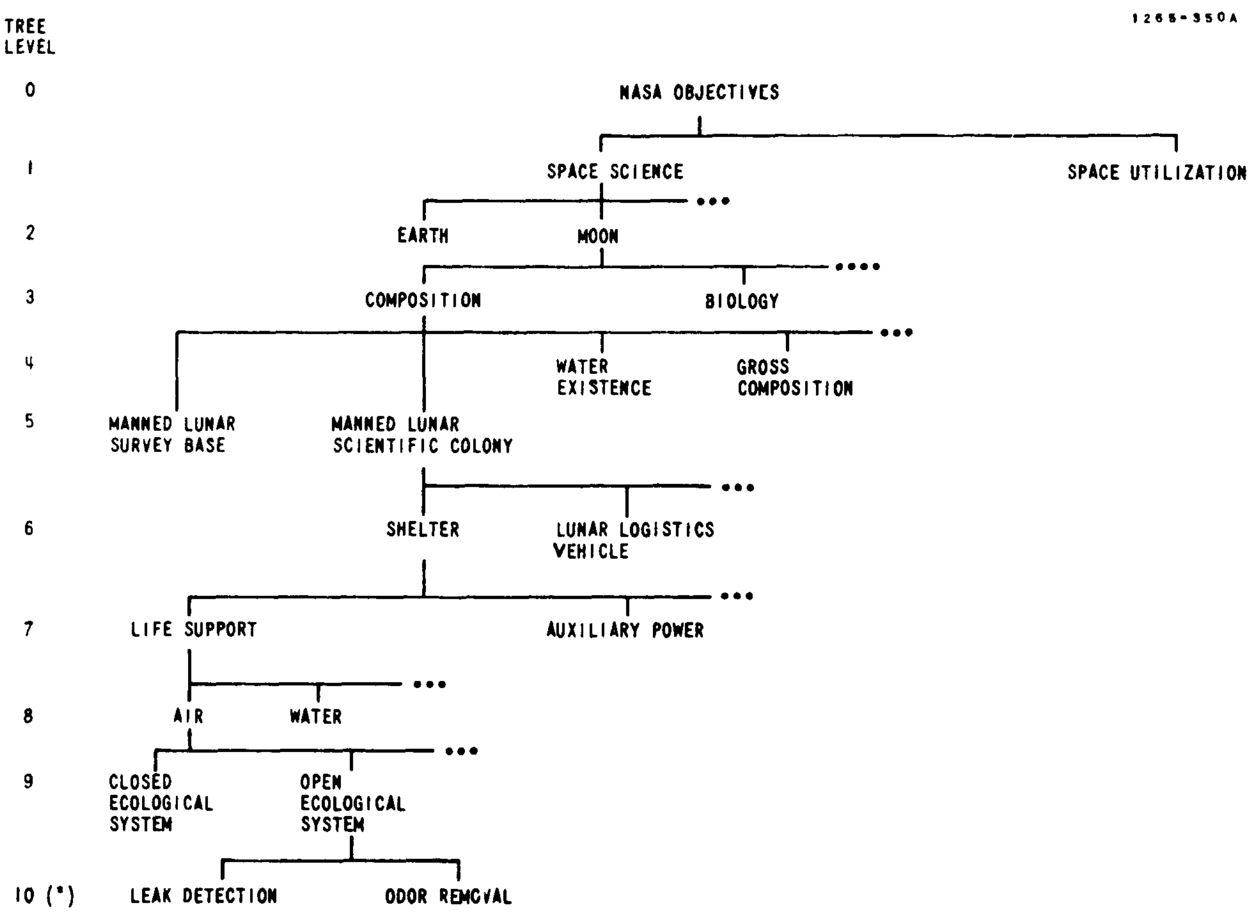

FIGURE 2-1. SAMPLE TREE STRUCTURE

- Level six identifies the Systems of which the concepts are composed. For example, the Synchronous Meteorological Satellite consists of a booster, a spacecraft, and a ground support facility.

- Level seven identifies and defines requirements for Subsystems for each system from a standard list of 14 space subsystems. An example is found on the spacecraft system of the Manned Lunar Orbiter, the subsystems of which include auxiliary power, life support, communication, and vehicle.

- Level eight identifies Functional Elements of the subsystem. These are major sections of the subsystem. An example within the life support system is: air, water, food, temperature-pressure-humidity, and medical/psychological.

- Level nine identifies Alternate Configurations for solution of the requirements. Alternates, for example, of the Manned Mars Lander propulsion subsystem are a solid core nuclear engine or a gaseous core nuclear engine.

- Level ten identifies the Technological Deficiencies associated with each configuration. For example, the technological deficiencies for the gaseous core nuclear engine just discussed are thrust vectoring, cooldown and startup capability, nuclear shielding, and research and development required.

The lower half of the tree then outlines a proposed mission, discusses its configurations, and poses problems for the various alternatives. Table 2-1 shows the number of Series IA elements in each level.

2.3.1.2 Relevance Guide. Having identified the tree elements for the selected concepts in the lower half (levels 5 - 10) of the tree and having organized the logic interests in the upper half (levels 0 - 4) of the tree, PATTERN now develops a common reference point from which to make relevance judgements. The required commonality is provided by the Relevance Guide, one of the primary items of documentation. The PATTERN Relevance Guide consists of a compilation of material relevant to judgements among the elements of the tree structure. The Guide fills the need developed by the fact that very few, if any, individuals are intimately acquainted with all details of the elements in the wide range identified. Particularly in the upper half of the tree where broad categories are defined, discrimination among elements is difficult without the establishment of a common reference. The Relevance Guide fills the

TABLE 2-1. NUMBERS OF ELEMENTS IN EACH LEVEL OF THE SERIES IA RELEVANCE TREE

Level Name	Number of Elements
0	1
1	2
2	15
3	68
4	301
5	46
6	195
7	786
8	687
9	761
10 (*)	2329

commonality requirement by stating the principal facts and interest points at each node and thus provides a reference of facts which should be considered in making the judgements necessary at each relevance node. Volume I of the Guide, General Space Science and Utilization, discusses material in the upper half of the tree including a review of U. S. and Soviet objectives and abilities in space, a discussion of the relevance of prestige as a criterion, a definition of the difference between scientific exploration of space and the utilization of space, an outline of the basic reasons for interest in the targets included on the tree, a description of the fields of interest and likely benefits from space flight, and a description of principal scientific tasks and scientific interests in each interest area. This represents a definition and an amplification of the elements identified on the tree with the emphasis on reasons each is relevant.

Volume II, Concepts, describes the lower half of the tree. It discusses the more than forty concepts considered in this study and details the elements included at each level. When an element was identified as encompassed by present design capability or by presently programmed product design (NASA Phase D), the element was labeled state-of-the-art and was not further detailed. The important output of this volume is its structured list of technological deficiencies and their relationship to the technical requirements of each concept.

Volume III, Technology Document, summarizes and discusses the state-of-the-art of and foreseeable, promising developments in each subsystem.

Each element of the tree at these levels is discussed and its technical problem areas described. This document serves as the guide for discrimination among the elements at the subsystem (seven) level and below. It is also a survey of highlights of present technology in a wide range of fields from auxiliary power to space vehicle structures.

2.3.1.3 Criteria. Another important sector in PATTERN concerns the criteria used to judge the relative value of the elements of the tree. Having reviewed the documentation concerning the various elements, one still requires criteria as a basis for assigning relevance numbers to elements of the tree. The criteria were selected to represent those factors which would be important in making the particular decision. Criteria were then assigned relevance numbers in the same fashion as were tree elements. The judgements represent the relative value of the selected criteria in deciding among the elements at a node. The study used the same criteria across any given level of the tree, the number of criteria varying with the level. In total, six unique criteria were used:

- The material benefit to mankind: this included literal, direct benefits such as improved communications, spinoff to industry or technical breakthroughs, but excluded such things as economic pump-priming and educational or training benefits.

- Improved human knowledge with remote or no clearly identifiable benefits: this criterion accounted for the benefits provided by a general increase in the field of knowledge of a subject.

- National prestige: this accounted for the assessment of the national and international impact of U. S. actions in space. This particular criterion is discussed in detail in Volume I of the Relevance Guide.

- Relative importance of an element to its node: this required a judgement of the significance of performing one scientific task rather than another. The criterion was used to discriminate at the task (four) level among tasks applying to a field of interest.

- Relative capability achieved: this was used at the concept (five) level to judge relevance of the concepts to the field of interest. It required a judgement of the capability of the concept in accomplishing the objectives of a field of interest.

- The importance of upgrading present capability: this was the principal criterion in the lower half of the tree. The judgement it required is, restated, to measure the relative value of committing further development on one element against development on another. For example, on the basis of information presented in the Relevance Guide and on personal experience, the relevance assigner would determine which element is more valuable to upgrade and establish its importance. Then, relative judgements are made such as this element is two times more important to upgrade, this one five times less important and so on. A slight variation of this criterion was used at the Technological Deficiency (ten) level where the need for upgrading, rather than importance, was used. The variation is self-explanatory.

The relative value of these criteria varied at each decision level. These values were used in determining the final relevance data.

To maintain the "relevance to National Space Objectives" orientation of the output ranking, many criteria concerning particular interests were deleted. Such criteria as the suitability of particular experimental equipment and the relevance of an element to a particular agency's charter are, for example, factors which could be added as a filter after the basic relevance rankings are made.

2.3.1.4 Relevance Assignment. Having structured the tree, provided a data reference point, and reviewed the criteria, we now are ready to assign relevances to the tree elements.

Selection of personnel to assign relevance is one of the more important phases of PATTERN since it is on individual expertise that the data is established. The ideal individual is one who is a decision-maker at the level on which he is determining relevance. For example, the ideal man at the subsystem level would be a systems engineering manager since he actually makes the decisions of this type. It is highly desirable to have judgements made at each level by personnel either directly involved in decision-making at that level or by staff personnel familiar with the responsibility of decision-making at that level. The mix of experienced personnel making judgements at each level varies according to level.

Along with the requirement for experience at the decision-making level, other important factors include open-mindedness, integrity, and an understanding of the objectives of the technique. Open-mindedness is required since each judge must listen for reason behind the arguments of the others during the discussion periods. Integrity means that one maintains his well-founded opinion so long as he remains convinced of its accuracy, even though, say, his supervisor is in the session and judging differently. Understanding of the technique allows the introduction of some measure of commonality into the relevance assignment. It has been found by Honeywell that most judges will have a generally similar conception of what and why they are assigning relevance.

The size and composition of the working group varies as we move down the tree. Usually the largest group possible assigns relevance to the upper half of the tree to provide a broad base of judgement. After the concept (five) level, however, advantage should be taken of specialized expertise. For example, propulsion men should assign relevance to the propulsion subsystems and technological deficiencies, guidance men to the guidance subsystems, and so forth.

Personnel unacquainted with the PATTERN technique should be given a short briefing on PATTERN techniques and the relation of elements on the tree. Then they should be allowed time adequate to have familiarized themselves with the Relevance Guide and to have thoroughly studied the criteria. After a short briefing on criteria and the section under consideration, the group should be ready to begin.

Appendix C discusses the details of assigning relevance including completing ballots, assignment technique, criteria weight, and other important factors.

2.3.2 Experiments

A sampling of sixty experiments was provided by the NASA technical monitor. The experiments were representative of those projected for the Saturn I-B missions. They included both scientific and technical experiments. Scientific experiments were related to the task (four) level. They were measured by their contribution to the field of interest on the scale provided by the tasks. Similarly, the technical experiments were related to the technological deficiency (ten) level and rated on their relative contribution to the particular alternate configuration.

The final result is a ranking of the sample experiments by their contribution to the identified elements on the Relevance Tree. Since each of the elements is ranked according to national need, the experiments gain relevance by making contribution to tasks or technological deficiencies.

Relation of experiments to tree elements was by keywords as discussed in Section 3 and Appendix C, Relevance Assignment.

2.4 COMPUTER

2.4.1 Master Program

The master computer program operates on the Burroughs 5500 at Marshall Space Flight Center, Huntsville, Alabama. It contains all information used in the sample rankings and is ready to use for rederiving tree relevance numbers or any other function the user may select (see Section 4.0, Updating and Data Management).

The computer is used to store the relevance tree data and to calculate relevance of the elements. It is necessary because of the large number of elements and the volume of material. Its major functions are sorting the data, ordering the data, and performing elementary mathematical manipulation of the relevance values. Use of the computer allows wide flexibility in access to and updating of the data.

The program accepts the identified tree elements and from them generates relevance ballots. After ballots are completed, the computer reprocesses and stores them. It then calculates relevance and generates selected listings of the data. It accepts the selected experiments and generates experiment ballots. After completion, the program reprocesses and stores the ballots as well as generating experiment output listings.

This procedure is divided into five phases:

- Phase 1 - Accept tree input and generate relevance ballots.
- Phase 2 - Accept completed relevance ballots and calculate average relevance.
- Phase 3 - Calculate total direct relevance of tree elements.
- Phase 4 - Accept experiment input and generate experiment ballots.
- Phase 5 - Accept completed experiment ballots and calculate experiment relevance.

All input to the computer program is by punched cards (or magnetic tape). Outputs are computer-printed ballots and selected listings of elements. The computer operates as a data bank providing rapid access to elements of the tree structure and the completed relevance and experiment ballots.

2.4.2 Techniques

PATTERN utilizes the computer language COBOL. COBOL was selected because of its ability to handle large files of data and its commonality properties from machine to machine. COBOL may be used with relatively small change on any computer, thereby minimizing programming time in switching to other computers such as the Honeywell 800 or the IBM 7094.

For a more detailed discussion of the computer program, see Appendix A.

Section 3

PROGRAM OUTPUTS AND KEYWORDS

This section will describe many of the varied outputs of the PATTERN study as they apply to the various types of planning activity. It was found in this study, as in different PATTERN studies by Honeywell, that once the PATTERN data bank has been generated, many ranking arrays may be developed.

3.1 PROGRAM OUTPUTS

Outputs from PATTERN are derived by the stored data in the computer (Relevance Tree) and from the three-volume Relevance Guide. The Relevance Guide contains concise descriptive material in all areas covered by the study. Its primary use is in assuring that all numerical values assigned the Relevance Tree element are founded on the same data. A secondary benefit of particular interest to the PATTERN user is the use of the reference data in mission systems and supporting technology planning from well-organized documented material.

The computer-stored Relevance Tree contains brief descriptions of each tree element which are sufficiently clear for a person with a working knowledge of PATTERN terminology to immediately identify the element. Each element is also coded in the computer in such a way (see Appendix A) that a fairly close description is available from the code number at each tree level.

Outputs from computer-stored Relevance Tree data provides quantitative planning data to the following types of planning activity.

- Experiment Planning (MSFC Experiment Coordination Office, etc.)
- Space Mission, Program, and Supporting Technology Planning (MSFC Advanced System Office, etc.)

Specific output data of interest to each of these activities is presented below.

3.2 EXPERIMENT PLANNING

Experiments in space are ranked in PATTERN on the basis of their contribution to either space tasks which, in aggregate, make up the total National Space Program or to Technological Deficiencies which limit present capability to perform these tasks. The value of a particular experiment is determined by the product of its contribution to the task or deficiency and the relevance or importance of that task or deficiency.

At present, quantities of up to 100 experiments per set can be ranked as a computer printout. If necessary, this capacity can be expanded considerably. Individual experiments from different groups can be compared if the same Relevance Tree data (see Data Management, Section 4) is used as a reference.

Under this contract Honeywell provided a complete Relevance Tree which was used to derive many of the data outputs listed below. Copies of these printouts are available from the computer-stored data.

Typical examples of the type of data available to the experiment planner from the present PATTERN system are:

1. Ranked space science, space utilization and supporting technology experiments in terms of long-range space goals.

2. Detailed breakdown of the specific tasks or deficiencies that each experiment contributes, together with the amount of total experiment relevance derived from its contribution to that task or deficiency.

3. Important space tasks or technical deficiencies where on-board experiments may improve present capability. Printouts of these tasks or deficiencies may be called for and possible experiments derived by considering the nature of the specific task or deficiency.

Procedures for calling these printouts are contained in Appendix A, Computer Program.

3.3 SPACE MISSION, PROGRAM, AND SUPPORTING TECHNOLOGY PLANNING

The PATTERN technique provided for ranked data on all Relevance Tree elements. These elements vary from the broad space objectives at the top level of the tree down through:

- Space Science and Utilization
- Fields of Interest (Science and Utilization)
- Tasks
- Concepts (to fulfill these Fields of Interest)

to specific technological deficiencies which limit each subsystem.

A wide variety of planning data can be obtained from the Relevance Tree data bank. Typical of these are:

1. Ranked lists showing the relative value of additional exploration or exploitation of space targets (Mars, Sun, Earth, etc.), space science or utilization fields of interest (composition, biology, communication, etc.), specific space tasks under each field of interest. Combination of these ranked lists are available which provide ranked lists within specific targets or fields of interest.

2. Rankings showing the total relative value of typical space concepts and supporting operational systems placed on the Relevance Tree.

3. Group relevance of upgrading present manned Earth orbital capability, lunar capability or planetary capability, etc., is available by summing these computer outputs.

4. Subsystem requirements ranked according to their contribution to specific space systems. Also available are grouped importance of across-the-board subsystem improvements.

5. Relevance numbers of selected subsystem configuration and Technological Deficiency. These can be used to judge the contribution to the national space program of selected improvements in these areas.

The above are typical of the types of ranked outputs that are available from PATTERN. Specific printouts in other areas of particular interest to various planning activities may be obtained as permitted by the computer program described in Appendix A.

3.4 KEYWORDS

Extraction of information from the Relevance Tree is facilitated by use in PATTERN of keywords at each level of the tree.

The keywords concept is one of categorization of related elements at a given level of the tree. Similar elements are grouped under a common term which may be requested of the computer. The listing from the computer includes the element and its relevance.

Keywords are also used to determine the relation of experiments to the tree elements. Appropriate keywords were selected for each experiment. The chosen tree elements were then ordered and printed on the experiment ballots. For a full discussion of keywords as applied to experiments and in general, see Appendix B, Keywords, and Appendix C, Relevance Assignment.

Section 4

UPDATING AND DATA MANAGEMENT

4.1 INTRODUCTION

This section provides guidelines for information updating and data management by Marshall Space Flight Center of the PATTERN system. These procedures have been derived from experience gained by Honeywell in applying PATTERN to many planning and decision areas. Based on this experience, Honeywell feels that these procedures provide maximum availability and utility of PATTERN data for rating experiments, future candidate systems, and supporting technologies.

4.2 ORGANIZATION

It is recommended that MSFC designate a central authority for all PATTERN data. This individual should have responsibility and authority over all aspects of handling, processing, and updating PATTERN data.

By placing an engineer with broad systems and technological experience as the central authority, overall integrity and technical content can be maintained in the system with support provided on a part-time basis in each specialized area. Detailed procedures using a central PATTERN authority are contained in the task descriptions below.

Management of the PATTERN system is divided into the following areas:

- Data Management
- Information Updating

For convenience, each of these areas will be discussed separately, although one should realize that they are not entirely separable.

4.3 DATA MANAGEMENT

The data contained in the PATTERN system are stored in two forms, namely, the Relevance Guide and the Relevance Tree.

The Relevance Guide, published in three volumes, contains the background information needed to assign value judgements to the Relevance Tree. The data should be made current whenever new material becomes available. Particular care in reviewing appropriate sections of the Relevance Guide is necessary prior to any changes in either the Relevance Tree structure or in the numerical assignments. A data must be included on each revision of the Relevance Guide so that proper correlation is maintained between the numerical judgements and the data on which these judgements were made.

A Relevance Tree is stored on the computer tape and may be recalled on demand from the computer program. Volume I of the Relevance Guide contains detailed descriptions of the top four levels of the Relevance Tree. Volume II contains detailed descriptions of levels five through ten of the tree. The computer data bank should be considered the "data master" with necessary explanatory material contained in Volumes I and II of the Relevance Guide.

The Relevance Tree master (computer tape) is designated by a serial code which is printed on all computer printout forms so that the data can be traced to its proper source. Under the contract the data generated by Honeywell has been serialized as IA data.

Any revision of output of the computer programming or of interpretation of data stored in the computer using as its base the same numerical judgements or balloted relevance carries only an advancement of the letter designator, such as "Series IB", "Series IC", etc. Where new elements, data, or numerical values have been added to the Relevance Tree, a numerical series advance is used, such as "Series IIA", . . .

An appropriate file should be maintained at MSFC so that the status of the computer-stored Relevance Tree is always available.

The PATTERN contract authority at MSFC should have complete control over the data bank. All requests for data, revisions of the data bank, and updating changes should be coordinated through him.

4.4 INFORMATION UPDATING

As new or expanded information becomes available, it should be incorporated in the PATTERN system so that these factors are available for experiment rankings and other printouts. The method for incorporating these changes is provided under this contract.

Suggested additions or corrections to PATTERN data are first detailed describing in full the new data, the reason for considering the data in PATTERN, and the urgency with which the data should be incorporated. This written description is then filed with the central PATTERN authority for review and inclusion in the data bank.

At a convenient time and particularly before major printouts of PATTERN data for planning purposes, all filed changes should be incorporated in the PATTERN data as follows.

The central authority should assemble a group that represents the experience or technical expertise required to make the judgements necessary to incorporate the corrections. This group, under the guidance of the central authority, should (1) pass on whether to make the recommended change or not, (2) decide on the appropriate Relevance Guide section(s) and Relevance Tree node(s) at which to make the change, and (3) make the necessary changes on the computer printout sheets using the process described below.

Changes to the Relevance Guide should be made by reprinting the specific page or section that is influenced by the change.

Relevance Tree changes should be made by calling out the appropriate node on the tree and then making the necessary changes with a red pencil on the ballot form. These changes can be sent back to the MSFC Computation Laboratory for direct key punch and addition to the stored computer information.

Where changes to numerical values (balloted relevance) are desired, the change should be made directly on the node printout. This printout can be called for with or without the old balloted relevance data. The new relevance values will then be calculated.

The central authority should then summarize all changes in an action memo to the designated MSFC Computation Laboratory personnel together with specific instructions on timing and reserializing the data.

It is recommended that wherever possible "block" changes be made in the PATTERN data so that the status of stored information is easily understood by all people working with PATTERN.

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Appendix A

COMPUTER PROGRAM

The computer program keeps track of the many elements of the tree and performs the calculations necessary to develop relevance numbers.

A.1 TREE CODING

The program uses a numeric code designator to catalog data. Knowledge of the meanings of the characters of the designator is valuable since it allows rapid discovery of a great deal of information about the element.

The maximum number of characters in a designator is ten. The first character always indicates the tree level of the element.

TABLE A-1. TREE CODING

0	Summary Level
1	Purpose of Endeavor
2	Target of Endeavor
3	Field of Interest
4	Task
5	Concept
6	System
7	Subsystem
8	Functional Element
9	Alternate Configuration
10 (*)	Technological Deficiency

A.1.1 Level 0 (Summary Level)

Level 0 consists of one element designated 0000000001. This is the summary level which ties the two branches of the tree together.

A.1.2 Level 1 (Purpose of Endeavor)

Level 1 consists of two elements designated:

Utilization	1	1
Space Science	1	2

Level Designator (first character)

Utilization/Space Science Designator (U/SS) (second character)

When the U/SS designator is even, the item belongs to the Space Science branch of the tree. When odd, it belongs to the Utilization branch. The second character of the code name in the top half of the tree (levels 1 through 4) indicates this property.

A.1.3 Level 2 (Target of Endeavor)

Level 2 has a three-character designator: 2 2 L

Level (first character)

U/SS (second character)

Target Identification (third character)

In the top half of the tree, the third character is alphabetic representing the mnemonic for the Target of Endeavor. The mnemonics are:

21G	Gravity Environment	22L	Moon
21M	Material Environment	22M	Mars and Satellites
21P	Relative Position	22N	Saturn and Satellites
21R	Radiation Environment	22S	Sun
21V	Vacuum Environment	22Y	Extra-Solar System
22C	Comets and Asteroids	22V	Venus
22E	Earth	22Y	Mercury
22J	Jupiter and Satellites		

A.1.4 Level 3 (Field of Interest)

Level 3 has a four-character designator:

	3	2	L	K
Level	3			
U/SS		2		
Target			L	
Field of Interest				K

The fourth character at levels 3 and 4 represents the Field of Interest mnemonic. These are:

A	Atmosphere and ionosphere	M	Manufacturing
B	Biology	Q	Intelligence Data
E	EM Radiation	1PR	Communications
G	Magnetic Field	2 R	Magnetosphere and Radiation Belts
I	Composition and Characteristics	T	Transportation
K	Composition	1PZ	Navigation Aids
L	R&D Laboratory	2 Z	Geodesy and Mapping

A.1.5 Level 4 (Task)

Level 4 has a six-character designator:

	4	2	L	K	02
Level	4				
U/SS		2			
Target			L		
Field of Interest				K	
Task Serial Designator					02

The last two characters represent the task serial but do not indicate what type of task.

A. 1. 6 Level 5 (Concept)

Level 5 has a five-character designator:

5 LD 02

Level — 5

Two Character Mnemonic — LD

Two Character Serial — 02

The two-character mnemonic indicates the location of the mission (first character of mnemonic) and the type of vehicle (second character of mnemonic). The two-character serial indicates whether the concept is manned (even) or unmanned(odd). The mnemonics are:

Locations (1st mnemonic character)		Vehicle Types (2nd mnemonic character)	
C	Comets and Asteroids	D	Descent (lander)
E	Earth	F	Flyby
J	Jupiter	I	Import
L	Moon	0 (zero)	Orbit
M	Mars		
P	Planet (unspecified)		
S	Sun		
U	Extra-Solar		
V	Venus		
Y	Mercury		

For example, 5JF01 would mean Unmanned Jupiter Flyby.

A. 1. 7 Level 6 (System)

Level 6 through 10 (*) are related to level 5. They are components of the concept. Each level designator adds a character to the previous level designator. Level 6 has a six-character designator.

6 LD02 S

Level

Concept

System

The sixth character indicates the system according to the following mnemonic:

B	Launch Booster	Y	Miscellaneous
G	Ground Support Facility	W	
S	Spacecraft	Z	
R	Rover	E	
M	Command and Re-entry Module	F	
P	Probe	X	
J	Orbital Booster	U	
X	Extra-Vehicular Activity Unit and Miscellaneous	V	
L	Lander and Miscellaneous		

A. 1. 8 Level 7 (Subsystem)

Level 7 has a seven-character designator, as follows:

7 LD02 S A

Level

Concept

System

Subsystem

The seventh character indicates the subsystem according to the following mnemonic:

A Auxiliary Power

D Data Processing

E Escape and Recovery

G Guidance and Navigation

H Life Support

I Task Instrumentation

M Checkout and Maintenance

N Detection, Discrimination, and Tracking

P Propulsion

R Communications

S Stability and Control

T Simulation and Training

V Vehicle

Y Display

A.1.9 Levels 8, 9, and 10 (*) (Functional Element), (Alternate Configuration), (Technological Deficiency)

Levels 8, 9, and 10 (*) add an additional digit each for the designator:

8LD02BG1

9LD02BG11

*LD02BG111

The additional character goes from 1 to 0 dependent on the number of elements at the node.

Functional Element

8LD02BH1 → 9LD02BH11 → *LD02BH111

8LD02BH1 → 9LD02BH21 → *LD02BH211

8LD02BH2 → 9LD02BH22 → *LD02BH221

8LD02BH2 → 9LD02BH22 → *LD02BH222

In summary, element codes are to be structured as shown in Table A-2.

TABLE A-2. ELEMENT CODES

Level	Element Code	Code Meaning
0	0	First character of each code is the level 0-9, *
1	1A	A - Purpose Designator
2	2AB	B - Target Designator
3	3ABC	C - Field Designator
4	4ABCDE	DE - Task Serial
5	5FGHI	FG - Mnemonic Designator HI - Concept Serial
6	6FGHIJ	J - System Identifier
7	7FGHIJK	K - Subsystem Identifier
8	8FGHIJKL	L - Functional Element
9	9FGHIJKLM	M - Alternate Configuration
10(*)	*FGHIJKLMN	N - Technological Deficiency

In this nomenclature, there is columnwise consistency within levels 0 through 4 and within levels 5 through 10(*). There is no relationship between a level 5 code and the element codes for levels 0 through 4. Within each of the two groupings (0-4 and 5-10), each element code is identical to the code for the node above in the tree except for the addition of one new character at right (2 new characters at level 4). Thus, each character of the code after the level number gives identification information about a particular level of the tree.

In the element code, the first character is 0-9 or "*". The following characters are selected from the set 0-9, A-Z (no special characters or imbedded blanks are permitted). Although the computer programs carry all these codes as 10-character fields, punched element codes must be of the exact length shown in the table, for example, all level three codes consist of four non-blank characters, left justified.

The tree elements are coded in two types of formats. The first, shown in Figure A-1, is used for all titles and key words. The second, Figure A-2, is for the field of interest (3 to 5) level connections necessary because of the discontinuity in the tree. The Figure A-2 format connects the upper and lower halves of the tree.

Note that each card must have an "E", "C", or "N" punched into Column 1. All cards must be placed into a single deck. The tree input may be ordered in any manner except that node cards ("N") for a given element must follow the "E" card for that element. Criteria cards need not precede the "E" and "N" cards but may be anywhere in the input.

A. 2 CRITERIA CODING

Criteria was assigned a two-character designator; the first character indicates the level of the criterion and the second character the serial of the criterion:

01 Material benefit to mankind within ten years

02 Material benefit to mankind in ten to twenty years

Criteria are coded in the format shown in Figure A-3.

A. 3 EXPERIMENT CODING

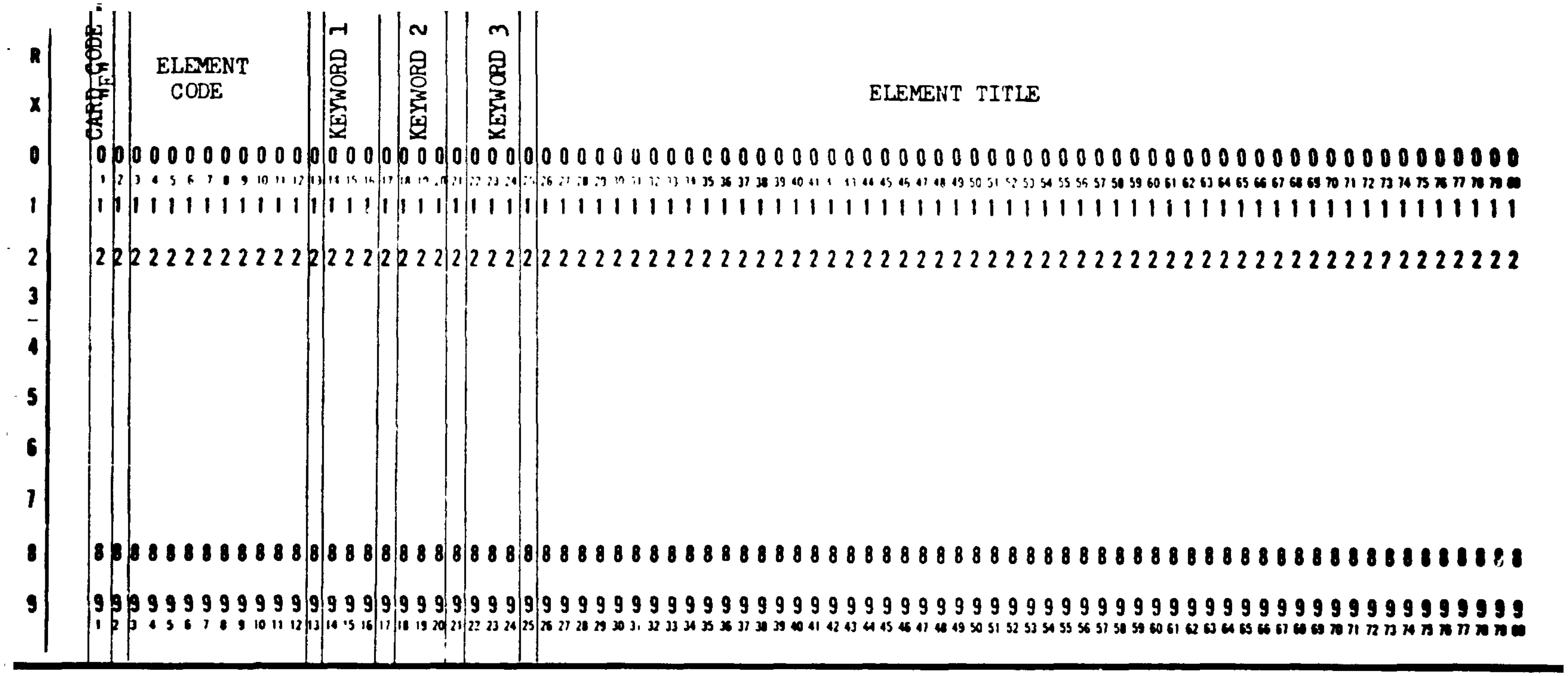
Experiments were assigned four-digit designators, the first digit of which was a 3 or a 9 to indicate the level to which the experiment applied. The last three digits were serial indicators.

A. 4 PHASE 1

After creating the tree input in the formats described in Figures A-1, A-2, and A-3 and having the data keypunched, the input is ready to be accepted by the computer programs of Phase 1.

The diagram for Phase 1 is illustrated in Figure A-4.

1265-353A



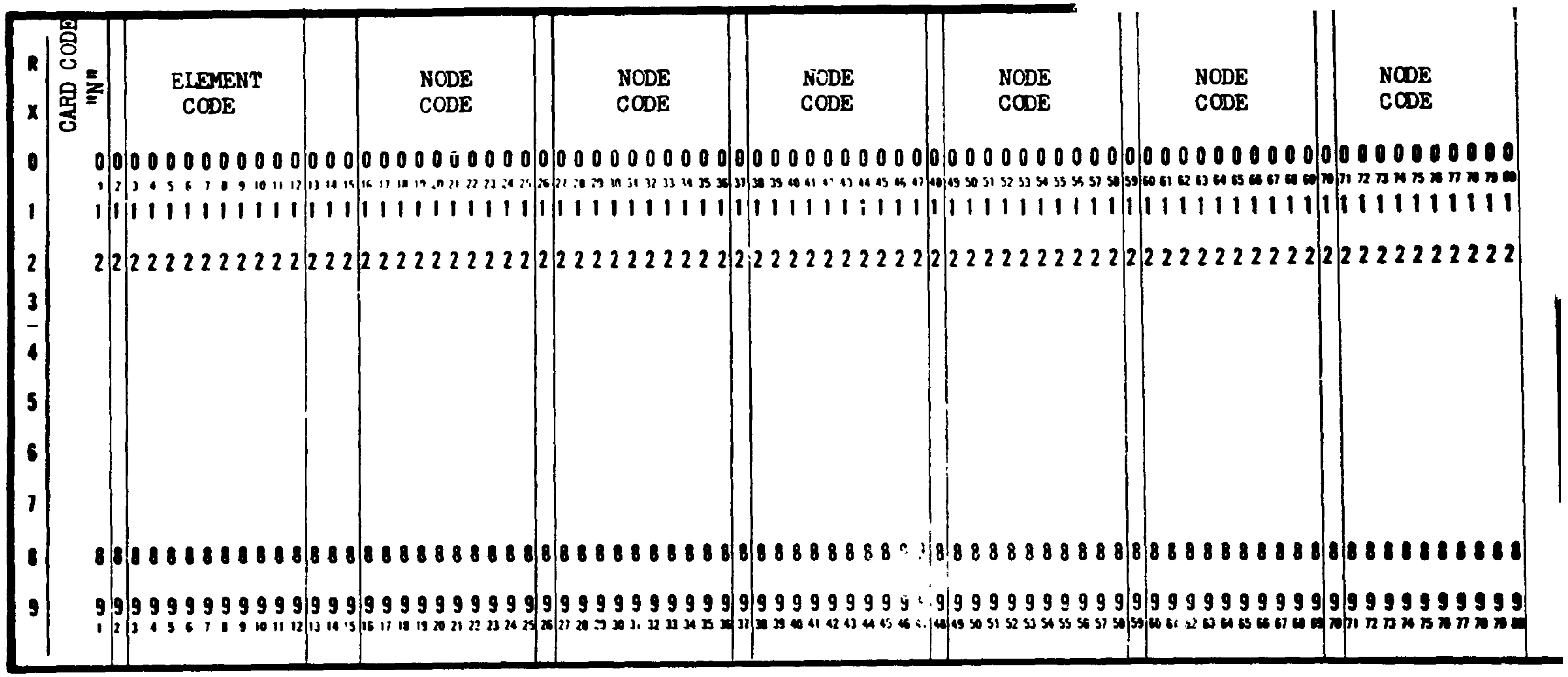
Title ELEMENT CARD

For Program NASA/PATTERN PHASE I

Remarks One "E" card must be input for each element of the tree.

FIGURE A-1. ELEMENT CARD

1265-355A

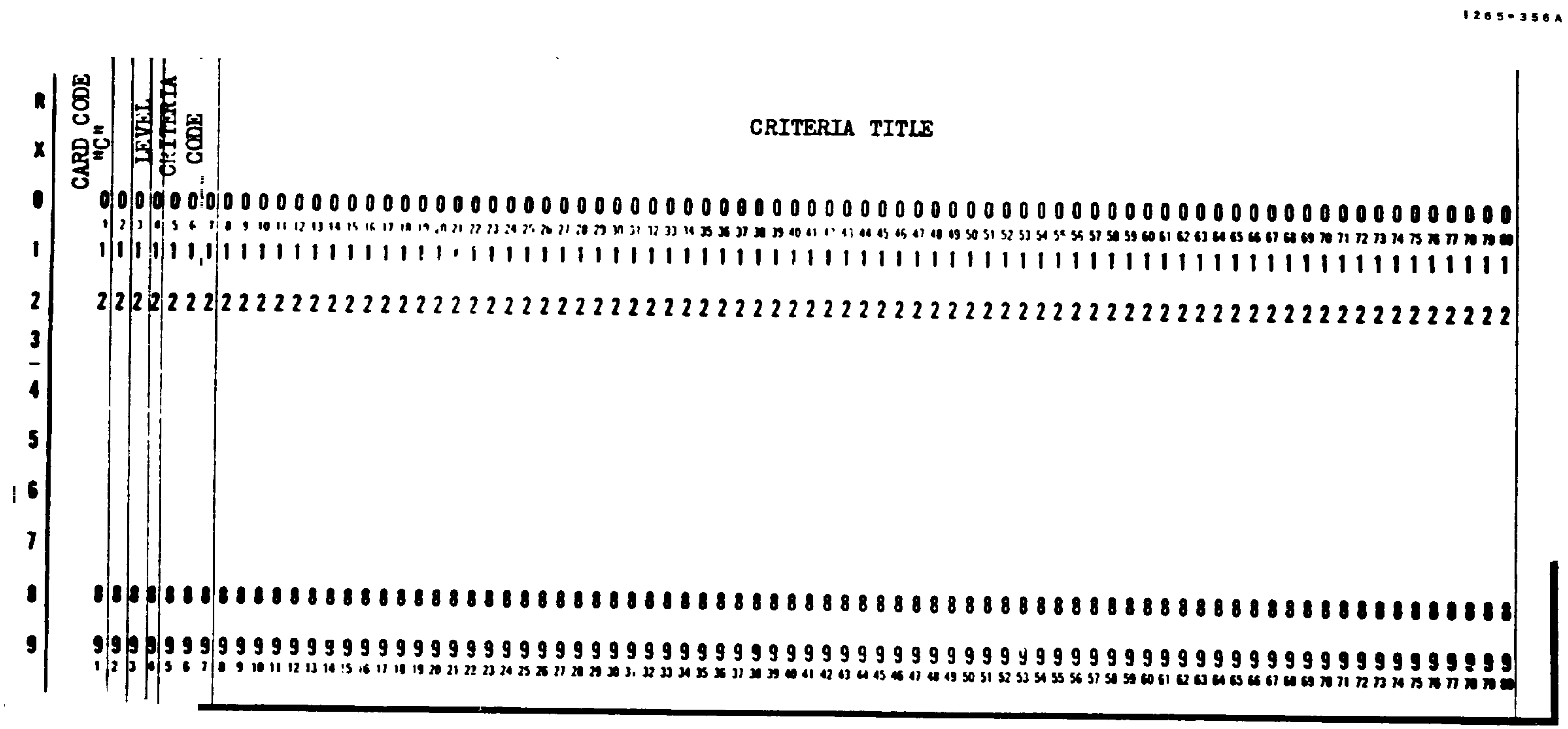


Title NODE CARD

For Program NASA/PATTERN PHASE I

Remarks From one (1) to eight (8) "N" cards will follow each "E" card for level five (5). Columns 3-12 will duplicate the element code of the "E" card. Node codes represent level three (3) elements to which the level five (5) element connects.

FIGURE A-2. NODE CARD



Title CRITERIA CARD

For Program NASA/PATTERN PHASE I

Remarks No more than four criteria cards for a given level.

FIGURE A-3. CRITERIA CARD

1265-3518

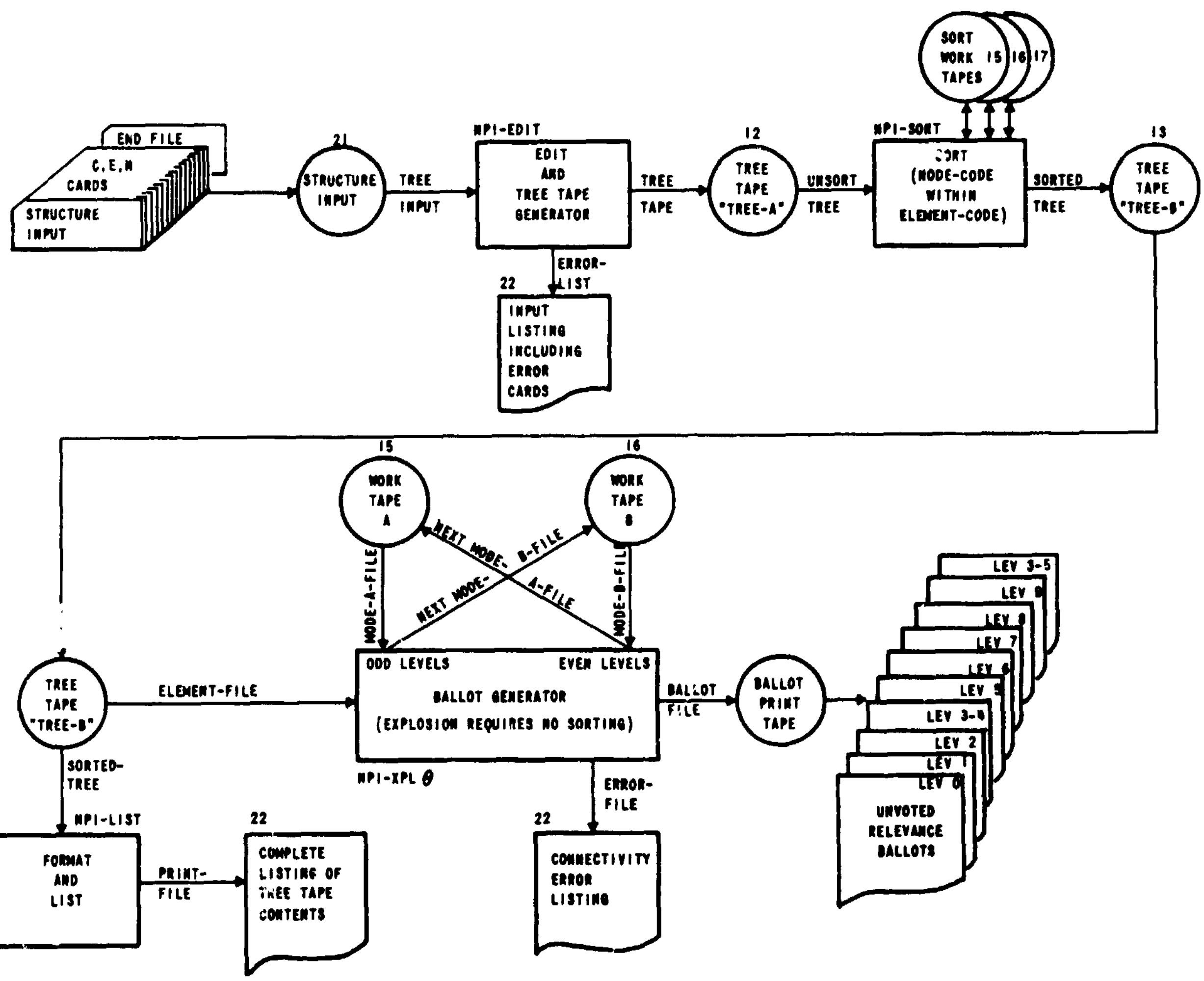


FIGURE A-4. PHASE 1 DIAGRAM

Phase 1 consists of four programs: NP1-EDIT, NP1-SORT, NP1-LIST, and NP1-XPLO. NP1-EDIT accepts the tree structure input and generates a valid tree tape only when there are no errors in the tree structure coding. NP1-EDIT also generates a complete listing of the structure input as well as tagging any error cards rejected for the reasons listed in Table A-3.

TABLE A-3. ERROR COMMENTS BY NP1-EDIT

IMPROPER CARD CODE	(Must be C, E, or N)
IMPROPER LEVEL CODE	
DIGIT(S) IN KEYWORD	(Keywords must be all alphabetic when present)
TITLE IS MISSING	(Applies to E or C card)
CRIT-CD NOT NUMERIC	(No alphabetics or blanks permitted in criteria codes)
N CARD NOT IN ORDER	(This means that a legal E or N card having the same element code did not precede the current N card)
ILLEGAL NODE CODE	(Must begin with the digit "3")
NODES EXCEED 48	(Maximum nodes per level 5 element)
LETTER O IN E CODE	
ELEMENT HAS NO NODES	(A level 5 element has no nodes or all node cards were rejected as error cards)
N CARD HAS NO NODES	
WRONG SIZE ELEM CODE	(Improper number of non-blank characters in element code of E card. Nodes on N card are not checked for size)

Note that the letter "O" is not legal in element codes, but is represented by zero.

Typewriter comments from NP1-EDIT are:

1. Cards Accepted: n

2. Cards Rejected: m

3. Cards Total: p (p = m + n)

4. Valid Tree Tape Generated, or
   No Tree Tape Generated. Correct Structure Input and Resubmit.

After correcting the tree input so that NP1-EDIT tags no errors, the user calls for NP1-SORT. This program sorts the tree input alphanumerically by node code within element code.

NP1-SORT lists on the com[illegible] typewriter the following quantities from the tree tape:

1. Total Criteria: aa

2-12. Level m Contains bbbb Elements

13. Tree Contains ccc Elements

NP1-LIST is optional. It produces an output listing of the sorted tree tape. It is useful for record and information purposes. It produces a blank line whenever a duplicate element of the tree is detected.

NP1-XPLO produces relevance ballots from the sorted tree tape as well as a list of possible errors in the tree. The ballots are in the order shown in Figure A-4. No ballots are produced with level 4 nodes. The criteria entered for level 4 are printed on the ballots for node level 3/element level 5.

NP4-XPLO will detect and tag any of the following possible errors:

TABLE A-4. ERROR COMMENTS BY NP1-XPLO

THIS NODE CONTAINS NO ELEMENTS	(hanging node)
THIS ELEMENT BELONGS TO NO NODE	(hanging element)
DUPLICATE ELEMENT ON TREE	
THIS NODE UNCONNECTED TO LEVEL 5	(hanging node at level 3)

A hanging node is a node which contains no elements. This is a possible non-error since state-of-the-art subsystems were not carried down the tree.

A hanging element is an element belonging to no node. This is an error and requires insertion of the appropriate element card in the next higher level. For example, 9LD02XR11 is tagged THIS ELEMENT BELONGS TO NO NODE. Correction would require insertion of 8LD02XR1, the node.

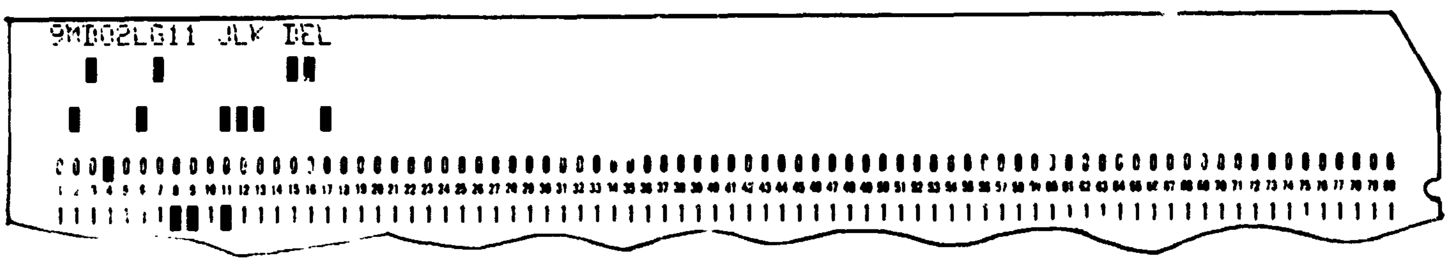
Duplicate elements must be deleted from the tree. The presence of errors will not affect the generation of ballots for elements not in error. In the case of duplication of element code, the first such item will be processed normally and the remaining ones will appear on the error list and will be excluded from all ballots. A hanging element will be retained in the explosion process and will be considered as a node at its proper level.

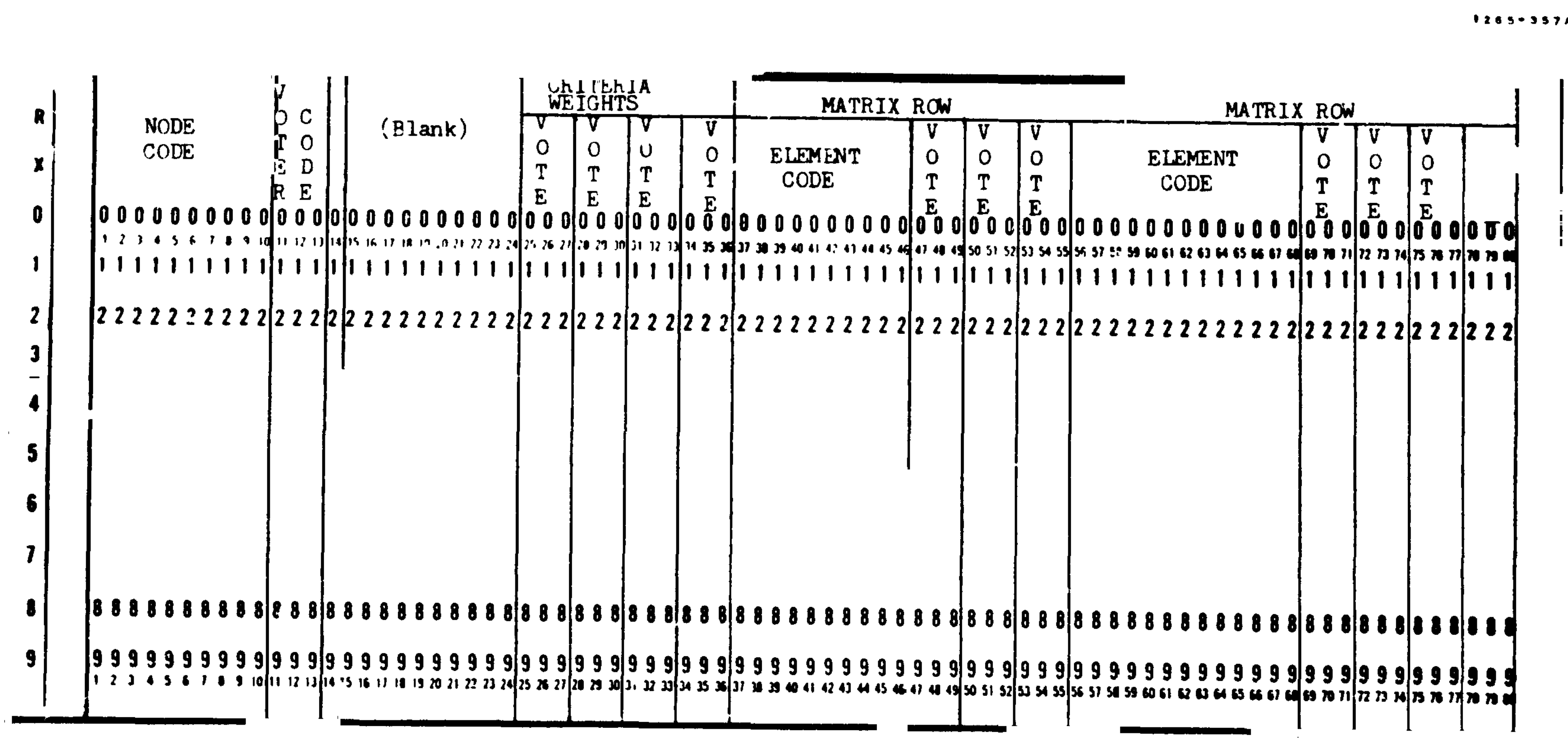
Phase 1 terminates with the generation of the blank relevance ballots. The ballot format is shown in Appendix C, Relevance Assignment.

A.5 PHASE 2

Phase 2 accepts and processes the completed relevance ballots. The completed ballots first go to key punching where relevant data is recorded. Data punched includes node code, voter code, element code, and relevance assignments, as well as criteria weights. Cards are punched in formats shown in Figures A-5 and A-6. The Phase 2 diagram is shown in Figure A-7.

Phase 2 consists of four programs: NP2-FILE, NP2-SORT, NP2-COM1, NP2-COM2. NP2-FILE accepts the relevance ballot cards, recording them on tape. It has an update feature so that once it has processed correct ballots, they need never be reprocessed. Instead, one may correct error ballots either by deletion or by straight replacement. Corrections are made by ballot so that all cards of the ballot must be reprocessed. To delete a ballot, write DEL in columns 15-17 of the correction card with the node code in columns 1-10 and the voter code in columns 11-13. The delete card would look like:



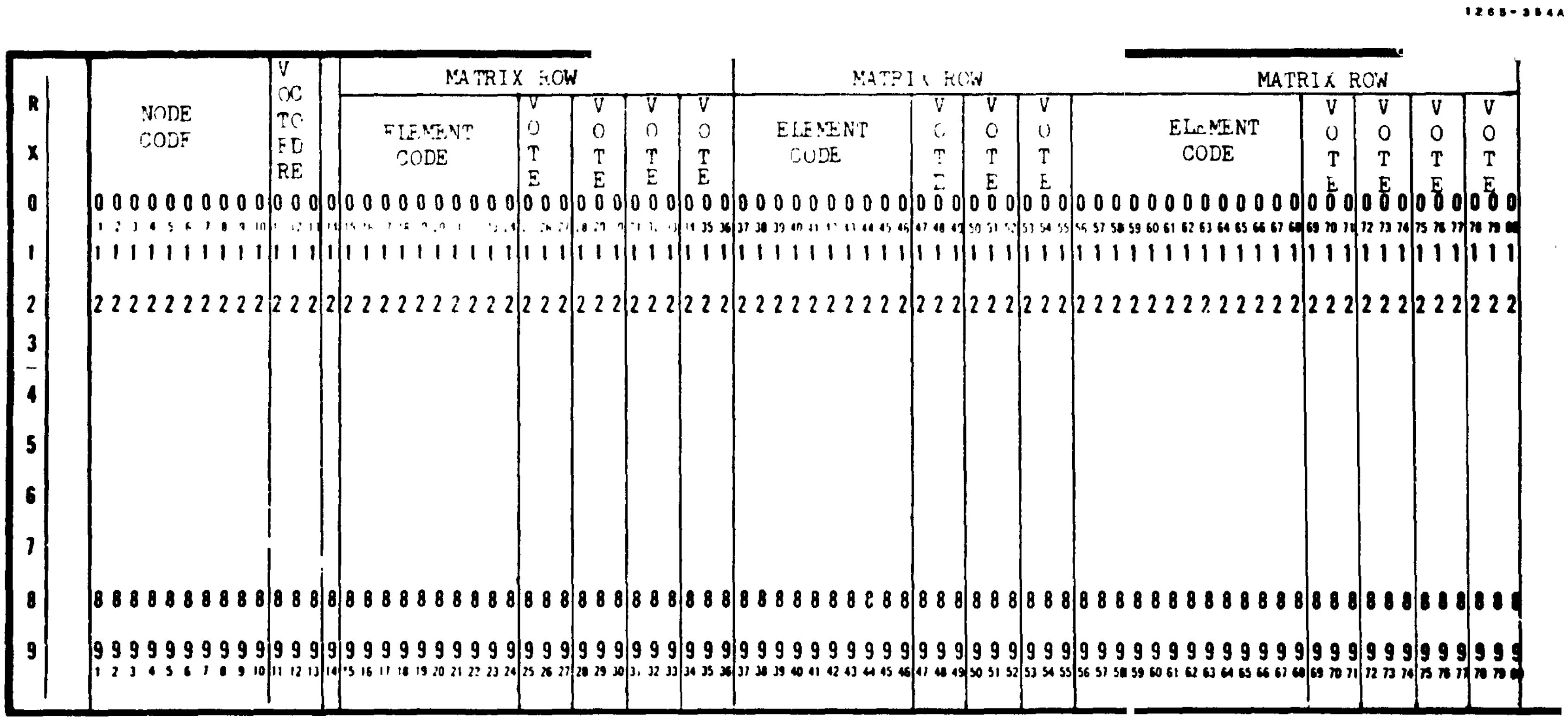


Title RELEVANCE BALLOT ID CARD

For Program NASA PATTERN, PHASE II

Remarks One ID card will be punched for each voted Relevance Ballot. Column 14 and Columns 15-24 are always blank.

FIGURE A-5. RELEVANCE BALLOT ID CARD



Title RELEVANCE BALLOT ROW CARD

For Program NASA PATTERN, PHASE II

Remarks Up to six row cards will follow the ID card when needed to record all votes on the ballot. Column 14 is always blank.

FIGURE A-6. RELEVANCE BALLOT ROW CARD

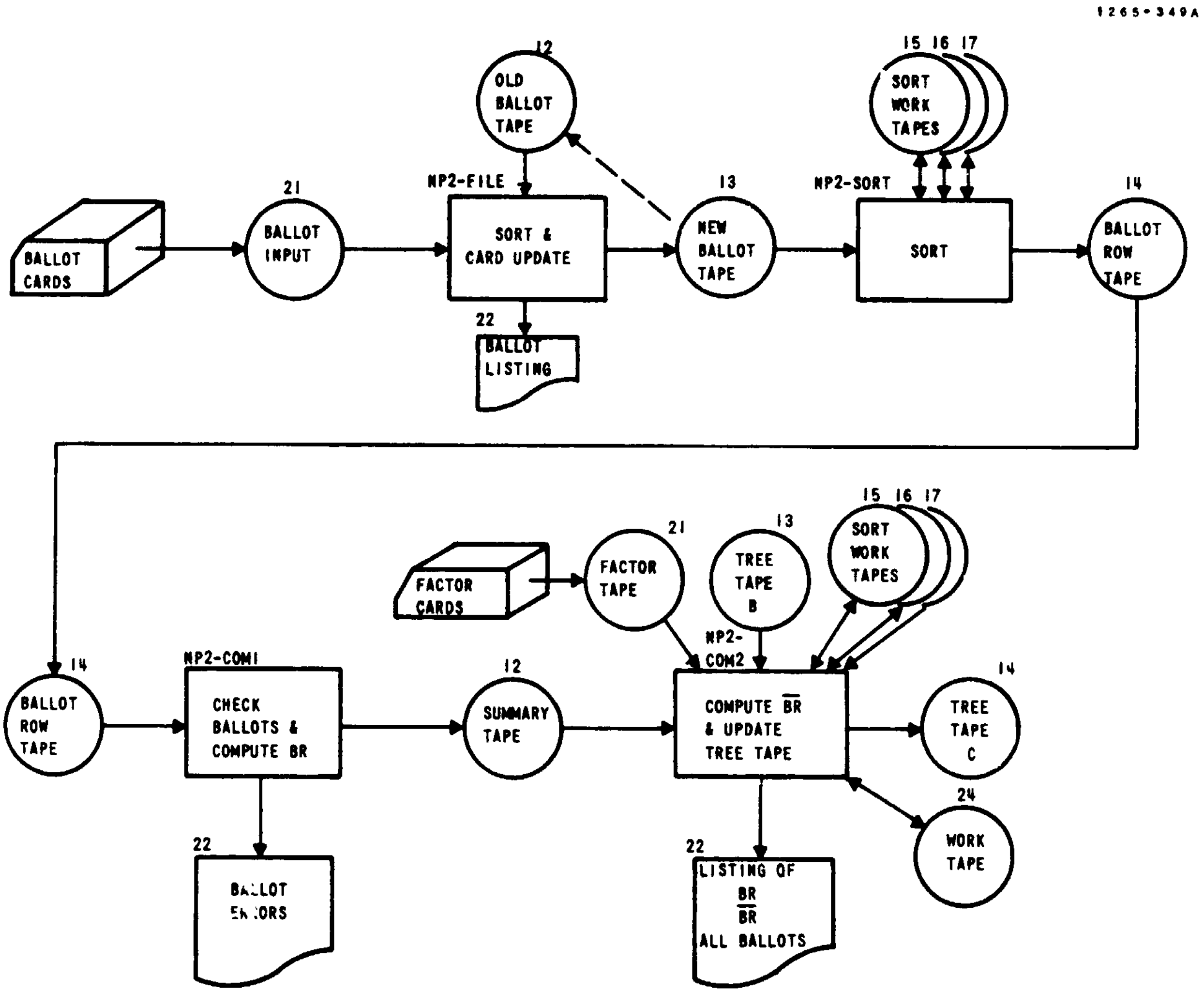
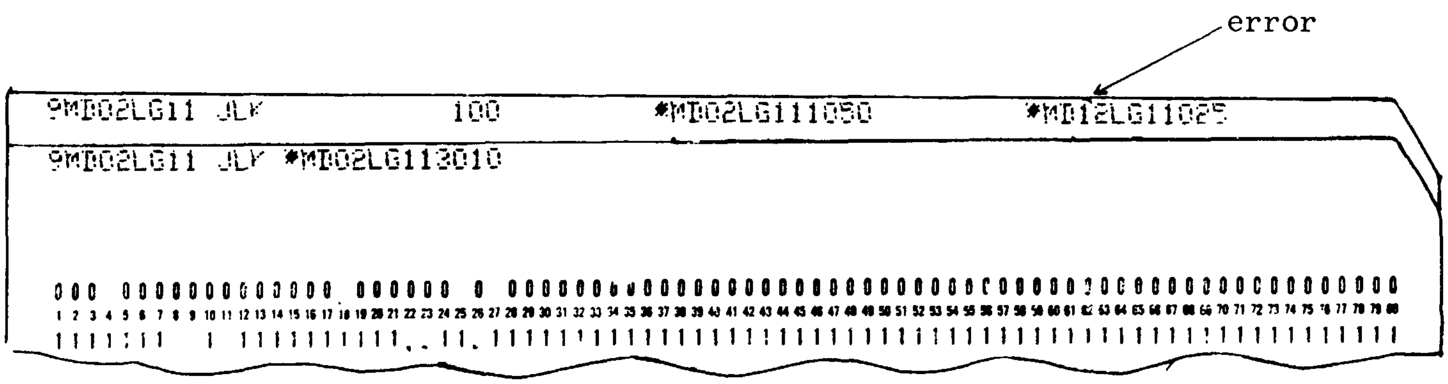
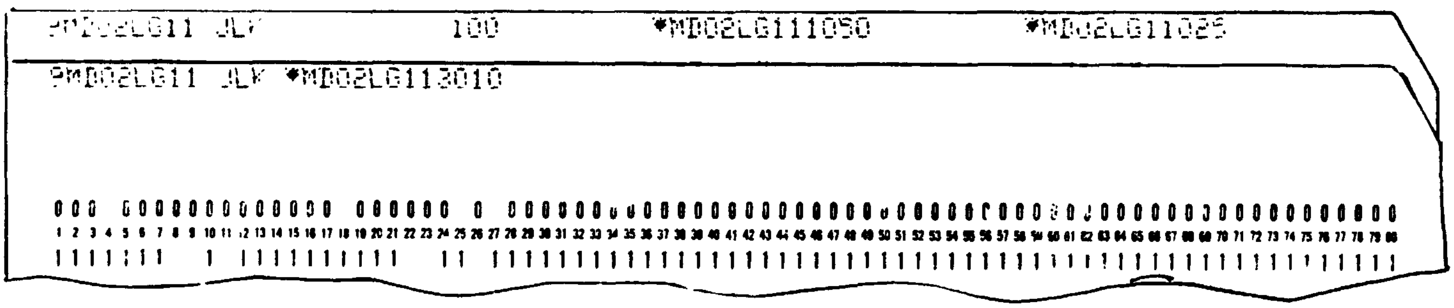


FIGURE A-7. PHASE 2 DIAGRAM

Replacement cards replace all cards of the given ballot with the data on the replacement cards. For example, we have a two-card ballot:



The error is that a 1 was punched instead of the zero. The replacement cards would be:



NP2-FILE generates a listing of ballot cards.

Next the user calls for NP2-SORT which sorts the ballots alphanumerically by element code within the node code.

Following NP2-SORT, the user calls NP2-COM1, which computes the balloted relevance (BR) for each ballot as well as the average BR and scales criteria. These calculations use the following relations. Recall that the ballot array is as illustrated in Figure A-8.

	Criteria 1	Criteria 2
Criteria Weight	A	B
Element 1	c	d
Element 2	e	f

FIGURE A-8. BALLOT ARRAY

The criteria are scaled to a sum of 1.0 following the equation:

$$\frac{\text{crit (i)}}{\sum_{i=1}^{n} \text{crit (i)}} = \overline{\text{crit}} \text{ (i)} \quad , \quad n = \text{number of criteria}$$

The relations used to calculate BR are:

$$Ac + Bd = BR(1)$$

$$Ae + Bf = BR(2)$$

All BR's for a given element m are collected and averaged:

$$\frac{1}{n} \sum_{i=1}^{n} BR(m)_i = BR(m)_A \quad , \quad n = \text{number of voters}$$

In the process of calculating BR_A, NP2-COM1 detects ballot errors and does not calculate BR_A's for such nodes. It, instead, prints an error list. Using the listing from NP2-FILE and this error list, ballot card input errors may be corrected.

TABLE A-5. ERROR COMMENTS BY NP2-COM1

FIRST VOTE AFTER ELEM-CODE IS BLANK
VOTE CONTAINS NON-NUMERIC CHARACTER
VOTE EXCEEDS 100
MISPOSITIONED OR EXTRANEOUS VOTE
CRIT-VOTES MISSING OR BAD ELEM-CODE
SUM OF CRITERIA VOTES IS ZERO
MATRIX WIDTH UNEQUAL TO LAST BALLOT
ELEMENT-CODE IS ZERO OR IS MISSING
IMPROPER LEVEL IN ELEMENT-CODE
ELEMENT-CODE MISMATCH TO LAST BALLOT
ROW WIDTH UNEQUAL TO CRITERIA-WT WIDTH
NUMBER OF ROWS EXCEEDS MAXIMUM OF 20
MATRIX HT UNEQUAL IN PRIOR 2 BALLOTS
WRONG LEVEL NODE-CODE
IMPROPER SIZE NODE-CODE
VOTER CODE IS IMPROPER
BR EXCEEDS 1.00 IN PRECEDING BALLOT

Typewriter comment from NP2-COM1 is:

1. No errors. Summary tape is valid,

or 1. nnnn ballot errors. Summary tape not valid.

The calculation output of NP2-COM1 is to a summary tape which is input to the final Phase 2 program, NP2-COM2.

NP2-COM2 calculates scaled BR_A's, symbolized by BR(m). Recall that the votes were unscaled. NP2-COM2 scales the BR_A's to the sum of 1.0 for all levels of the tree. Following the examples in Figure A-8, the relations used are:

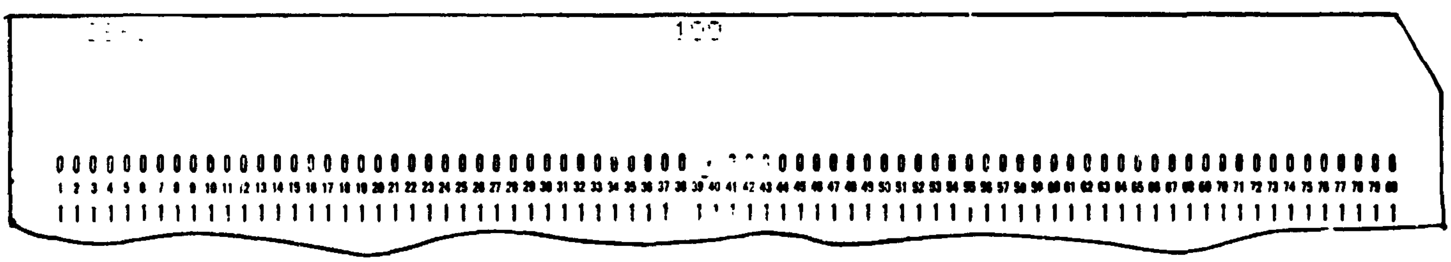
Level 0: $\overline{BR} = 1.000$

Other levels:

$$\frac{BR(m)_A}{\sum_{j=1}^{k} BR(j)_A} = \overline{BR}(m) \qquad m = 1, 2, \ldots, k \qquad k = \text{number of elements at node}$$

A required input to NP2-COM2 are the completeness FACTORS. The FACTORS are voted at the same time as the three to five level ballots, one FACTOR for each three level node. The FACTOR ranges from 0 to 100 and is a measure of the completeness with which the voters believe the concepts fulfill the field of interest. For example, Lunar Composition might have only one concept, Lunar Survey Base, relevant to it. The FACTOR would be 0.7 meaning Lunar Survey Base does a maximum of 0.7 of the field of interest. The FACTOR is multiplied by the BR(m) at the three to five level, prior to calculation of $\overline{BR}(m)$

FACTORS are entered in the following card format:



$\overline{BR}$'s are adjusted at level 4 and level 10(*) so that at each node the maximum $\overline{BR}$ becomes 1.0 and the others at that node are relatively adjusted.

NP2-COM2 outputs a listing of $\overline{BR}(m)$'s available for both reference and for input to Phases 3 and 4. In this process, NP2-COM2 matches the ballot tape to the tree tape, generating a new tree tape (Tree C) containing the tree and $\overline{BR}(m)$'s in the appropriate place. It also generates a list of possible errors where an element is listed on one tape but not on the other. Final corrections are made from this list to the tree tape and to the ballot tape to generate a valid Tree C.

Typewriter comment from NP2-COM2 is:

1. Number of tree mismatches is nnnn

A. 6 PHASE 3

Phase 3 accepts and processes $\overline{BR}(m)$'s as well as processing keywords.

The input is Tree C generated in Phase 2. The Phase 3 diagram is shown in Figure A-9.

Phase 3 consists of four programs: NP3-XPLO, NP3-RANK, NP3-LIST, and NP3-KEYW. NP3-XPLO accepts Tree C and calculates total direct relevance (TDR(m)). TDR(m) is derived according to the following relations:

level 0: TDR = 1.000000

levels 1 to 4:

$$\prod_{k=0}^{n} \overline{BR}(m_k) = TDR(m_n) \text{ where } n = 0, 1, 2, 3, 4, \text{ and } m_n \text{ is element at nth level} \quad (1)$$

levels 5 to 10(*):

$$\left\{ \sum_{i=1}^{w} \left[\prod_{j=1}^{3} \overline{BR}(1_{ij}) \right] BR(m_5{:}1_{i3}) \right\} \prod_{t=6}^{p} \overline{BR}(m_t) = TDR(m_p) \quad (2)$$

where w = 1, 2, 3, ..., z; z = number of level 5 elements
p = 6, 7, 8, 9, 10 and m_p is element of pth level
m_5 = element at level 5
$m5{:}1_{i3}$ = element at level 5 applied to ith element at level 3
1_{ij} = ith element at jth level

The bracket in equation (2) is equivalent to TDR (1_3).

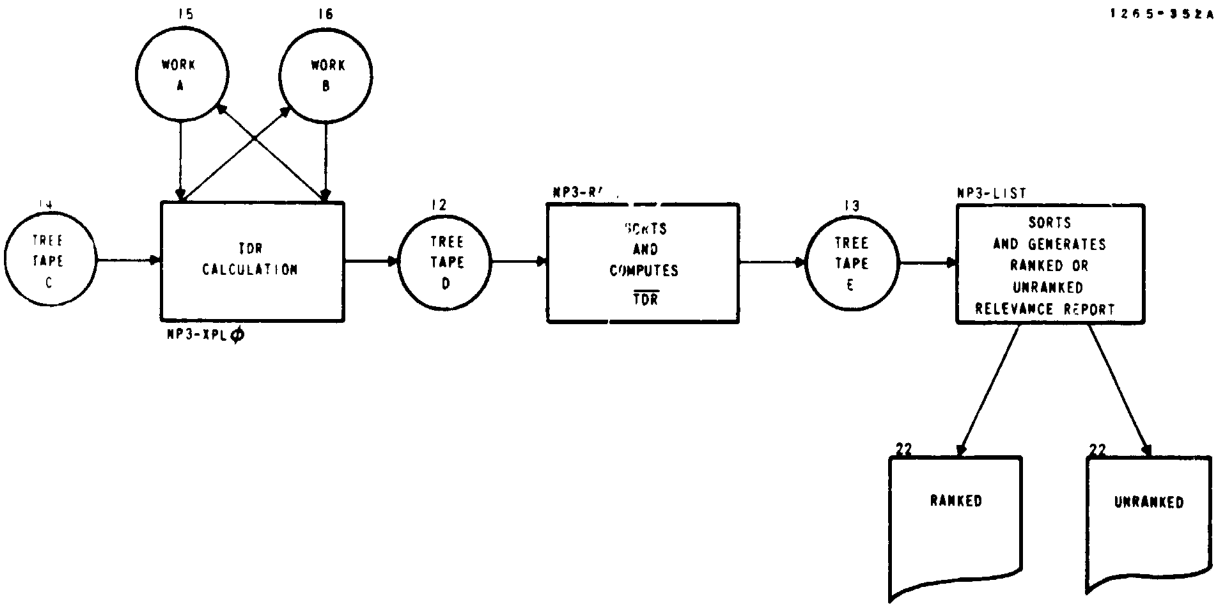


FIGURE A-9. PHASE 3 DIAGRAM

In the above equations, combinations of BR values for elements at different levels are constrained to those which are connected by the tree structure.

For example, we wish to calculate the TDR of 32SR. Using equation (1) above, we set n = 3 and define $m_1 = (12)$, developing

$$m_2 = (22S)$$

$$m_3 = (32SR)$$

$$\overline{BR}(12) \cdot \overline{BR}(22S) \cdot \overline{BR}(32SR) = TDR(32SR)$$

$$(.524) \cdot (.173) \cdot (.213) = TDR(32SR)$$

$$.0193 = TDR(32SR)$$

Or, we wish to calculate the TDR of *JF01SP111. Using equation (2) above, we set w = 8 since JF01 applies to 8 fields of interest. This develops

$$\begin{aligned}
\Big[&\overline{BR}(1_{11}) \cdot \overline{BR}(1_{12}) \cdot \overline{BR}(1_{13}) \cdot \overline{BR}(m_5 = 1_{13}) \\
+&\overline{BR}(1_{21}) \cdot \overline{BR}(1_{22}) \cdot \overline{BR}(1_{23}) \cdot \overline{BR}(m_5 = 1_{23}) \\
+&\overline{BR}(1_{31}) \cdot \overline{BR}(1_{32}) \cdot \overline{BR}(1_{33}) \cdot \overline{BR}(m_5 = 1_{33}) \\
+&\overline{BR}(1_{41}) \cdot \overline{BR}(1_{42}) \cdot \overline{BR}(1_{43}) \cdot \overline{BR}(m_5 = 1_{43}) \\
+&\overline{BR}(1_{51}) \cdot \overline{BR}(1_{52}) \cdot \overline{BR}(1_{53}) \cdot \overline{BR}(m_5 = 1_{53}) \\
+&\overline{BR}(1_{61}) \cdot \overline{BR}(1_{62}) \cdot \overline{BR}(1_{63}) \cdot \overline{BR}(m_5 = 1_{63}) \\
+&\overline{BR}(1_{71}) \cdot \overline{BR}(1_{72}) \cdot \overline{BR}(1_{73}) \cdot \overline{BR}(m_5 = 1_{73}) \\
+&\overline{BR}(1_{81}) \cdot \overline{BR}(1_{82}) \cdot \overline{BR}(1_{83}) \cdot \overline{BR}(m_5 = 1_{83})\Big] \cdot \\
&\Big[BR(m_6) \cdot BR(m_7) \cdot BR(m_8) \cdot BR(m_9) \cdot BR(m_{10})\Big] = TDR(m_{10})
\end{aligned}$$

Defining 1_{13} = (32JA), 1_{23} = (32JB), 1_{33} = (32JK), 1_{43} = (32JR), 1_{53} = (32JZ), 1_{63} = (32SE), 1_{73} = (32SG), and 1_{83} = (32SR), we recognize that $1_{12} = 1_{22} = 1_{32} = 1_{42} = 1_{52}$ = (22J) and $1_{62} = 1_{72} = 1_{82}$ = (22S) as well as that $1_{11} = 1_{21} =$

$1_{31} = 1_{41} = 1_{51} = 1_{61} = 1_{71} = 1_{81} = (12)$. Also m_6 = (6JF01S), m_7 = (7JF01SP), m_8 = (8JF01SP1), m_9 = (9JF01SP11), and m_{10} = (*JF01SP111).

Substitution yields:

$$\begin{aligned}
\Big[&\overline{\mathrm{BR}}(12) \cdot \overline{\mathrm{BR}}(22\mathrm{J}) \cdot \overline{\mathrm{BR}}(32\mathrm{JA}) \cdot \overline{\mathrm{BR}}(5\mathrm{JF01{:}32JA})\\
+&\overline{\mathrm{BR}}(12) \cdot \overline{\mathrm{BR}}(22\mathrm{J}) \cdot \overline{\mathrm{BR}}(32\mathrm{JB}) \cdot \overline{\mathrm{BR}}(5\mathrm{JF01{:}32JB})\\
+&\overline{\mathrm{BR}}(12) \cdot \overline{\mathrm{BR}}(22\mathrm{J}) \cdot \overline{\mathrm{BR}}(32\mathrm{JK}) \cdot \overline{\mathrm{BR}}(5\mathrm{JF01{:}32JK})\\
+&\overline{\mathrm{BR}}(12) \cdot \overline{\mathrm{BR}}(22\mathrm{J}) \cdot \overline{\mathrm{BR}}(32\mathrm{JR}) \cdot \overline{\mathrm{BR}}(5\mathrm{JF01{:}32JR})\\
+&\overline{\mathrm{BR}}(12) \cdot \overline{\mathrm{BR}}(22\mathrm{J}) \cdot \overline{\mathrm{BR}}(32\mathrm{JZ}) \cdot \overline{\mathrm{BR}}(5\mathrm{JF01{:}32JZ})\\
+&\overline{\mathrm{BR}}(12) \cdot \overline{\mathrm{BR}}(22\mathrm{S}) \cdot \overline{\mathrm{BR}}(32\mathrm{SE}) \cdot \overline{\mathrm{BR}}(5\mathrm{JF01{:}32SE})\\
+&\overline{\mathrm{BR}}(12) \cdot \overline{\mathrm{BR}}(22\mathrm{S}) \cdot \overline{\mathrm{BR}}(32\mathrm{SG}) \cdot \overline{\mathrm{BR}}(5\mathrm{JF01{:}32SG})\\
+&\overline{\mathrm{BR}}(12) \cdot \overline{\mathrm{BR}}(22\mathrm{S}) \cdot \overline{\mathrm{BR}}(32\mathrm{SR}) \cdot \overline{\mathrm{BR}}(5\mathrm{JF01{:}32SR})\Big] \cdot
\end{aligned}$$

$$\begin{aligned}
\Big[&\mathrm{BR}(6\mathrm{JF01S}) \cdot \mathrm{BR}(7\mathrm{JF01SP}) \cdot \mathrm{BR}(8\mathrm{JF01SP1}) \cdot \mathrm{BR}(9\mathrm{JF01SP11})\\
&\cdot \mathrm{BR}(*\mathrm{JF01SP111})\Big] = \mathrm{TDR}(*\mathrm{JF01SP111}).
\end{aligned}$$

Recognizing that the first three terms of each summand of the first product equals the TDR for the level 3 element, and substituting the numerical values for this and the last term in each summand, as well as substituting for the terms in the second product, yields:

$$\begin{aligned}
\Big[&(.0091) \cdot (.335)\\
+&(.0044) \cdot (.350)\\
+&(.0091) \cdot (.181)\\
+&(.0078) \cdot (.230)\\
+&(.0063) \cdot (.168)\\
+&(.0135) \cdot (.051)\\
+&(.0115) \cdot (.063)\\
+&(.0193) \cdot (.049)\Big] \cdot
\end{aligned}$$

$$\Big[(.659) \cdot (.030) \cdot (1.000) \cdot (.615) \cdot (1.000)\Big] = \mathrm{TDR}(*\mathrm{JF01SP111}).$$

Calculation yields:

TDR(*JF01SP111) = .0001392

The output from NP3-XPLO is a new tree tape which contains the tree structure and the TDR for each element.

The next program in Phase 3 is NP3-RANK which accepts the tree tape generated by NP3-XPLO, sorts it and finds the maximum TDR at each level. It then applies rank numbers and outputs a new tree tape containing the relevance tree structure, TDR's and rank numbers.

The next program is NP3-LIST which provides either a ranked or unranked listing by TDR. Both normalized and unnormalized TDR's will be displayed. TDR's are scaled by level, setting the largest element of the level equal to 1.0. The output listings are in the following format:

Rank	Element Code	Element Title	Keywords	TDR	Norm. TDR
0001	0000000001	NASA Objectives	AAA	1.00	1.00

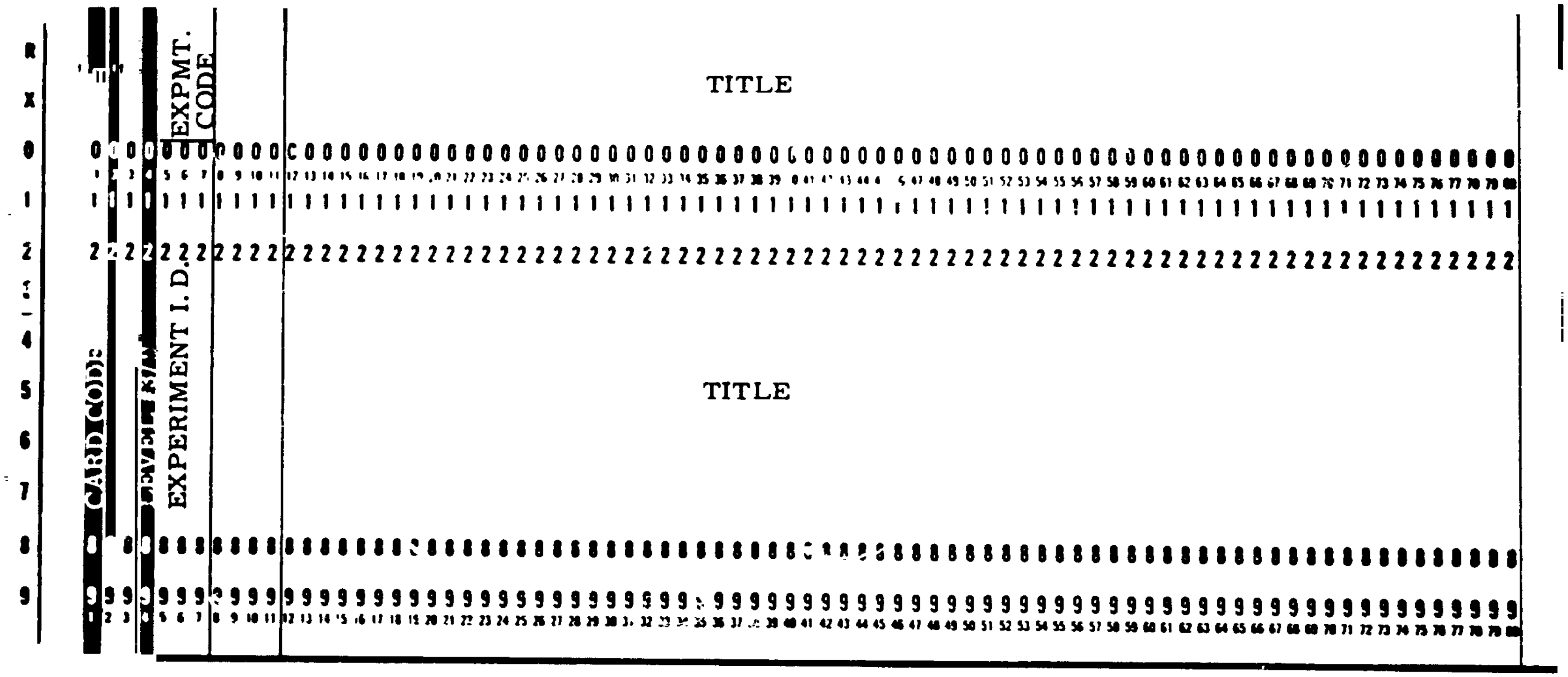
NP3-KEYW will list those elements having a given keyword only. This allows utilization of the keywords feature as discussed in Appendix B, Keywords. In such a listing, however, values of rank are appropriate to the collection of all elements at each level. The sum of TDR's for each keyword is also computed and printed.

A.7 PHASE 4

Phase 4 accepts the tree tape generated in Phase 2, which contains the BR's for the elements, accepts input cards containing keywords and identifiers, selects nodes and elements, and outputs blank experiment ballots.

The input cards are punched in the format shown in Figures A-10 and A-11. The Phase 4 diagram is shown in Figure A-12.

Phase 4 consists of two programs: NP4-EDIT and NP4-XBAL. NP4-EDIT accepts input cards and checks for errors, tagging error cards with one of the comments listed in Table A-6.

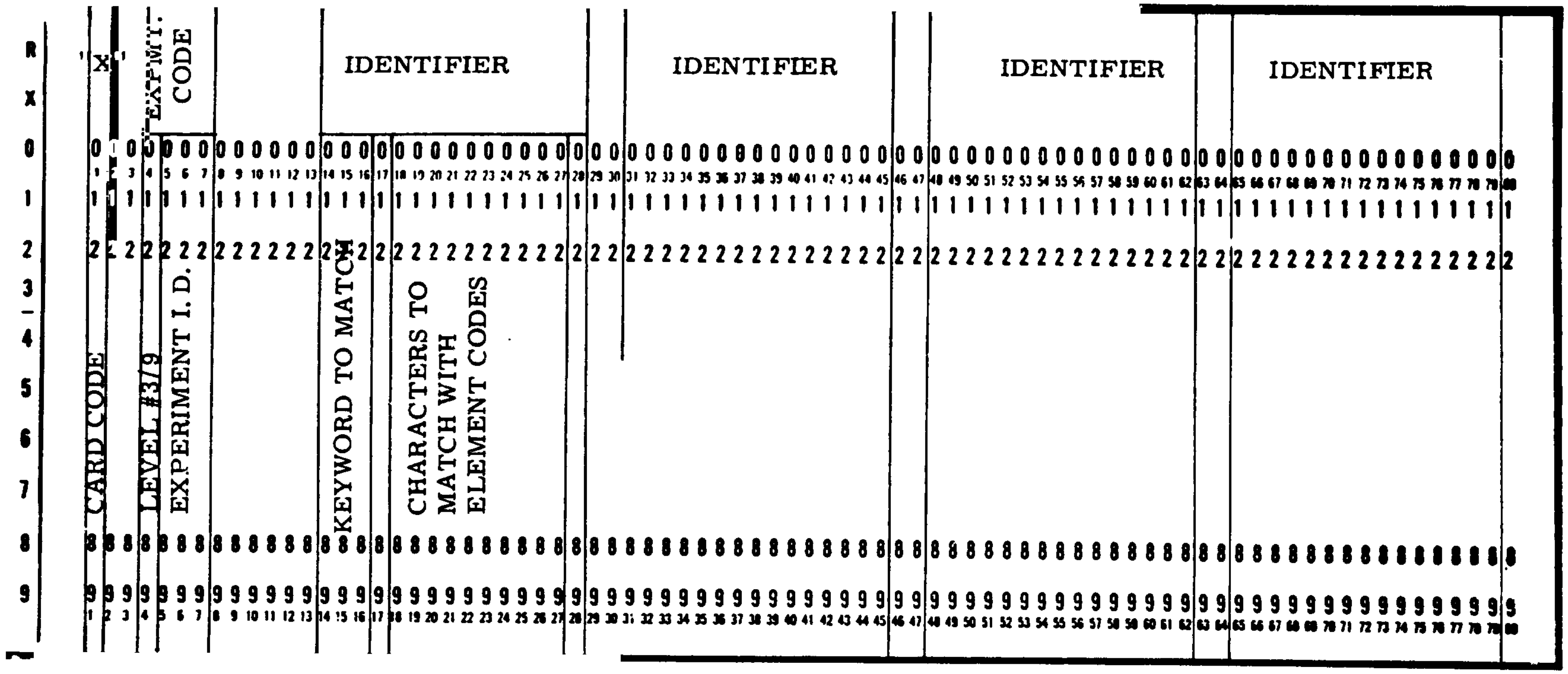


Title EXPERIMENT TITLE CARD

For Program NP4-EDIT

Remarks Card code is "T", Level Number "3" for Scientific Experiments, "9" for Engineering Experiments. One card per experiment.

FIGURE A-10. EXPERIMENT TITLE CARD



Title EXPERIMENT BALLOT SPECIFICATION CARD

For Program NP4-EDIT

Remarks Card C de "X", level number "3" for Scientific Experiment, "9" for Engineering Experiment. Up to 3 cards per experiment.

FIGURE A-11. EXPERIMENT BALLOT SPECIFICATION CARD

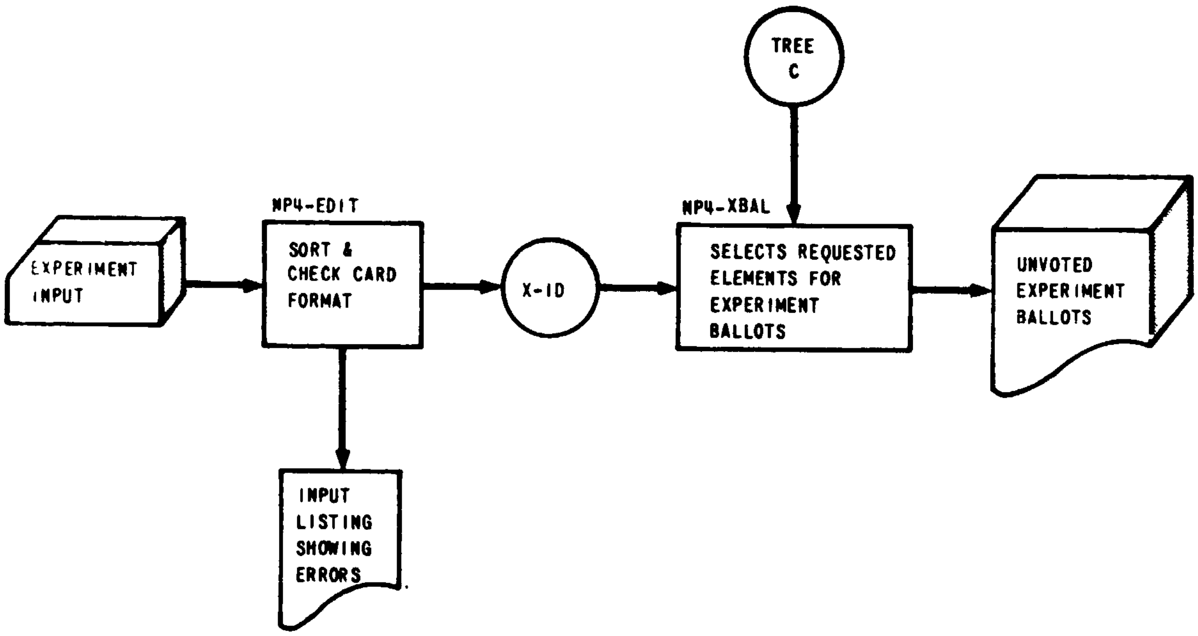


FIGURE A-12. PHASE 4 DIAGRAM

TABLE A-6. ERROR COMMENTS BY NP4-EDIT

BAD CARD CODE
NO TITLE CARD
NO IDENTIFIERS
TITLE BLANK
TOO MANY IDENTIFIERS
LEVEL OF X-CODE BAD

After correction of errors, NP4-EDIT sorts the input and stores it on tape.

NP4-XBAL accepts the tape generated by NP4-EDIT and the tree tape containing $\overline{BR}$'s. It collects the selected nodes and lists the elements under each node, sorting the elements to list that with the highest $\overline{BR}$ first and so forth. It then prints ballots in the format described in Appendix C, Relevance Assignment, Figure C-2.

A.8 PHASE 5

Phase 5 accepts the tree tape generated by Phase 3, which contains the TDR's for each element, accepts the completed experiment ballots, and calculates relevance of experiments. The completed ballot input card format is shown in Figure A-13.

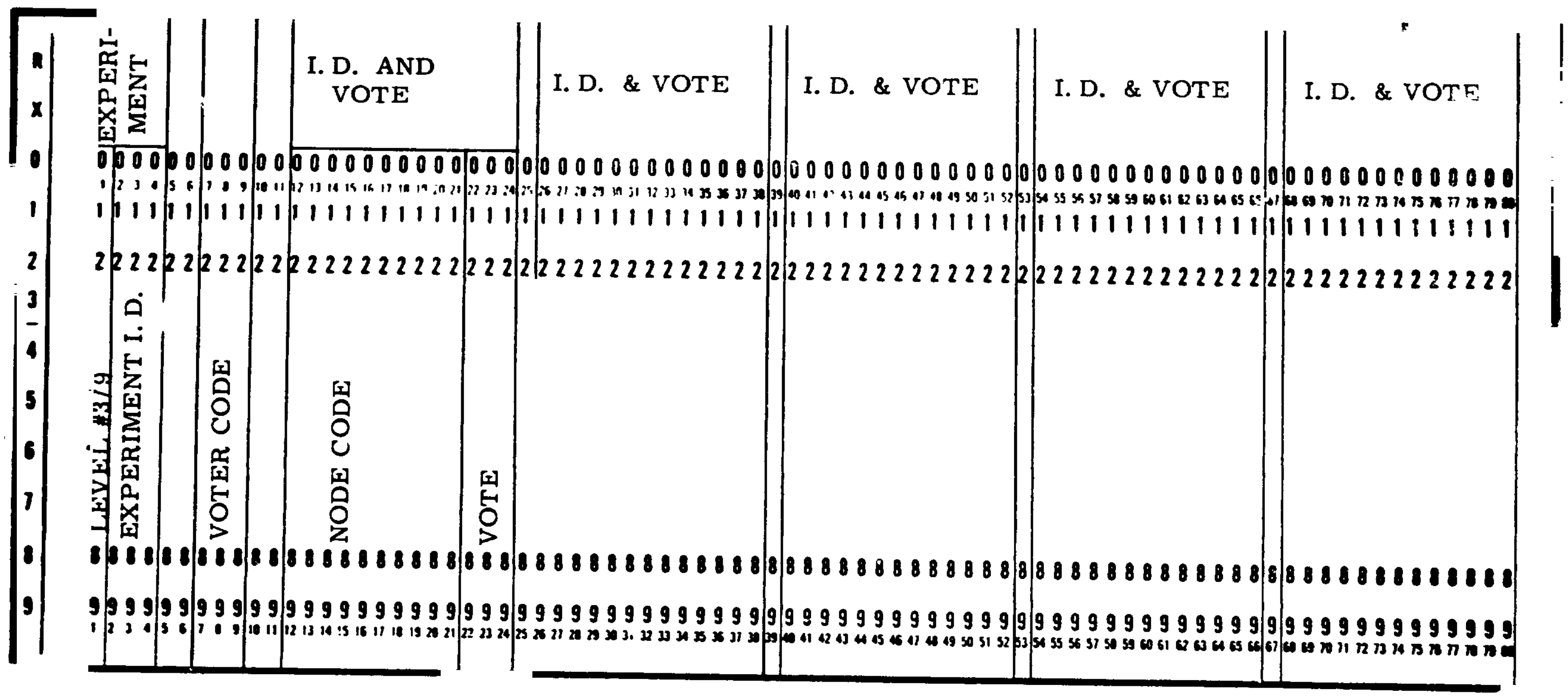
The Phase 5 diagram is shown in Figure A-14.

Phase 5 consists of three programs: NP5-EDIT, NP5-RANK, and NP5-REFF.

NP5-EDIT accepts the ballots on punched cards, checks formats and outputs an error list, sorting correct entries. The errors are tagged with one of the comments listed in Table A-7.

TABLE A-7. ERROR COMMENTS BY NP5-EDIT

BAD LEVEL
NODE CODE MISSING
VOTE MISSING
VOTE NOT NUMERIC
MISMATCH NO. NODES
MISMATCH NO. VOTERS
MISMATCH NODE CODE
ILLEGAL COL. PUNCHED



Title BALLOT INPUT

For Program NP4-TXRS

Remarks As many cards as needed. Node code left justified. Vote right justified and pre-zeroed.

FIGURE A-13. BALLOT INPUT

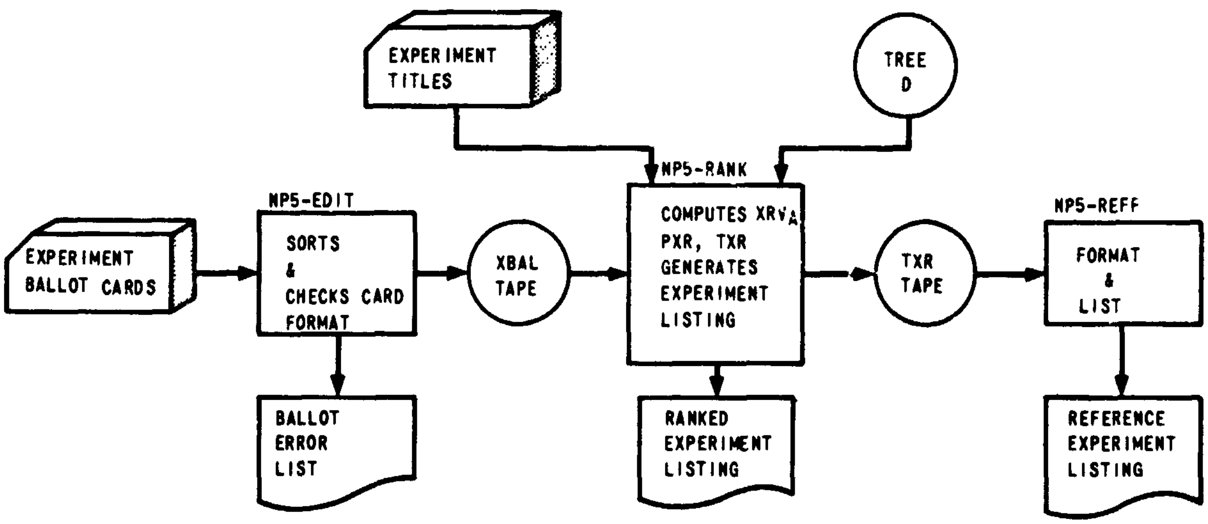


FIGURE A-14. PHASE 5 DIAGRAM

NP5-RANK accepts the input from NP5-EDIT and calculates average experiment relevance votes (XRV_A). The relation used is:

$$\sum_{i=1}^{n} \frac{XRV_i}{n} = XRV_A \qquad \text{where } n = \text{number of voters}$$

It then accepts the XRV_A's and the tree tape generated by Phase 3 containing TDR's and matches the XRV_A with the appropriate TDR to obtain the partial experiment relevance (PXR).

$$XRV_{Ai} \cdot TDR_i = PXR_i$$

It then calculates total experiment relevance (TXR) for each experiment by summing all appropriate PXR's.

$$\sum_{i=1}^{m} PXR_i = TXR \qquad m = \text{number of PXR's}$$

It then computes normalized TXR ($\overline{TXR}$) as:

$$\overline{TXR} = \frac{TXR}{\max TXR}$$

Ranking 1 provides the ranking of experiments.

RANKING 1

Experiment Rank	Experiment Code	Experiment Title	$\overline{TXR}$

The final program is NP5-REFF which provides the reference listing for experiments in the following format:

```
EXPERIMENT 3301   [illegible] OF SUNLIGHT REFL AND SCAT BY EARTH ATMOS   TXR IS [illegible]
                                                                          PXRi%
     31P[illegible]   INTELLIGENCE DATA                      TDR = .063[illegible]   66[illegible]
     32EA             AT[illegible]OSPHERE AND IONOSPHERE    TDR = .032[illegible]   34[illegible]
```

where $PXR_{i\%} = \dfrac{PXR_i}{TXR} \times 100$

Summarizing,

Phase 1 generates unvoted relevance ballots from the tree structure input.

Phase 2 generates average normalized balloted relevances ($\overline{BR}$) from the voted relevance ballots.

Phase 3 generates total direct relevance from the $\overline{BR}$'s.

Phase 4 generates unvoted experiment ballots from the $\overline{BR}$'s and keyword input.

Phase 5 generates total experiment relevance from voted experiment ballots and total direct relevance.

Major outputs are:

Phase 3: Total or selected TDR listings, ranked and unranked.

Phase 5: Experiment listings, basic and exploded.

Summary computer diagram is Figure A-15.

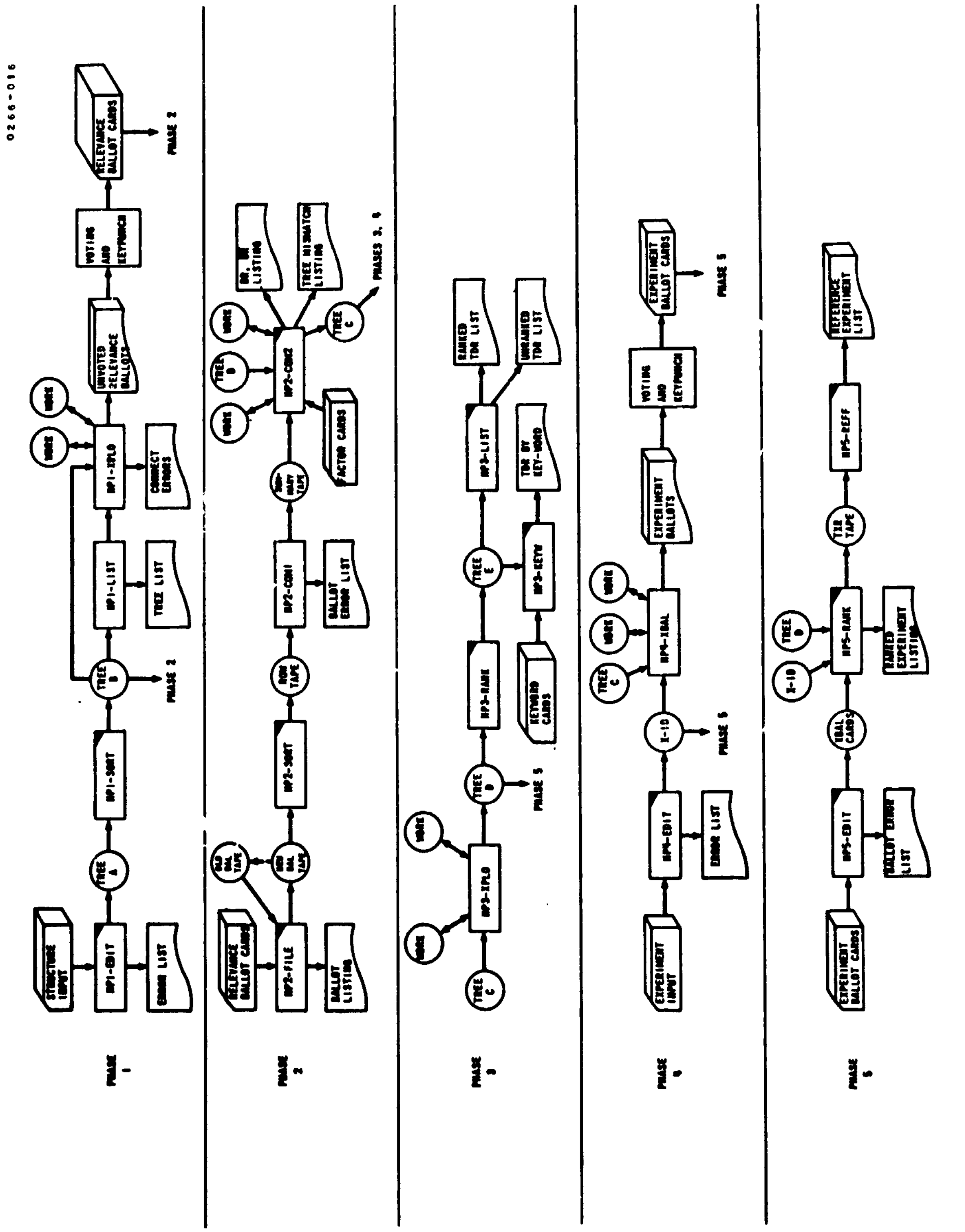


FIGURE A-15. SUMMARY COMPUTER DIAGRAM

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Appendix B

KEYWORDS

The keywords feature of NASA PATTERN enable rapid extraction of data from the tree. It allows selection of related groups of elements and displays them with the appropriate Total Direct Relevance values. The need for this feature arises from the fact that there are many similar, if not identical, elements on the tree at any given level. Displaying a list of related elements is, then, help in determining the magnitude of the problem area with which they are associated.

The output after calling the keywords feature is of two types dependent on whether one is preparing to rank experiments or whether one is searching for information. The former is discussed in Appendix C, Relevance Assignment. Output for information prints the keyword, the keyword title, the elements grouped by the keyword, and the proper TDR in the following format:

Keyword: AMT Modifier: 9LD02YZ11

Keyword Title: Tape Data Storage

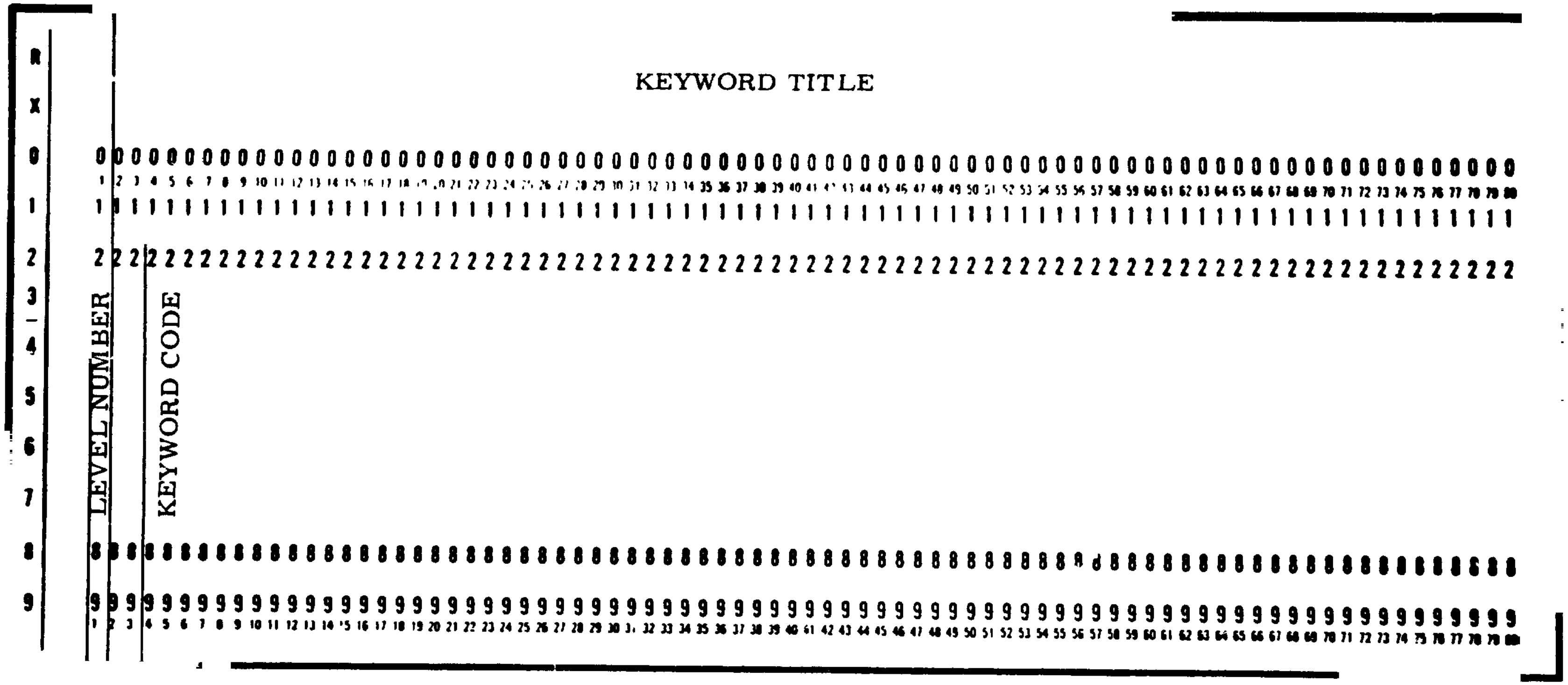
Element Code	Element Title	TDR
9LD02YZ11	Tape Data Storage	0.000005
9LD02YZ12	Tape Data Storage	0.000004

FIGURE B-1. KEYWORD OUTPUT FORMAT

The keyword consists of three alphabetic characters which are serially assigned to the selected groups. Use of alphabetic characters set a limitation on the number of unique keywords of 26^3 or 17,576. In the NASA tree approximately 900 unique keywords are identified. For experiment ballots, one may select a modifier which will edit the list of keywords or select a unique grouping of elements. The modifier consists of a 10-character word of the same format as an element code. The modifier operates by rejecting all element codes which do not have corresponding characters to the modifier. For example, to call all the Tape Data Storage elements at the 9 level on Mars missions, one would select the appropriate keyword, AMT, and designate the identifier (9M - - - - - - - - -). These inputs enter in the format indicated in Figures B-2 and A-11.

Note that keywords for Levels 0 - 2 are the element titles, as are those for Level 8, and hence no keyword code is assigned.

The list of the keywords to Series IA follows by level.



Title KEYWORD INPUT

For Program NP3-KEYW

Remarks One card per keyword.

FIGURE B-2. KEYWORD INPUT FORMAT

TABLE B-1. LIST OF AVAILABLE SERIES IA KEYWORDS

Level 3

FIELD OF INTEREST

Keyword	Code	Keyword	Code
Atmosphere	AAC	Mining and Manufacturing	AAF
Biology	AAE	Navigation Aids	AAH
Communications	AAJ	Particle and Electromagnetic Radiation	AAK
Composition	AAA	Photosphere	AAN
Corona	AAC	Planetary Systems Investigation	AAL
Electromagnetic Radiation	AAK	R&D Laboratory	AAG
Geodesy	AAB	Radiation Belts, Magnetosphere, and Magnetic Field	AAD
Intelligence Data	AAI	Shape	AAB
Ionosphere, Corona, and Atmosphere	AAC	Size, Shape, Mapping and Geodesy	AAB
Magnetic Field	AAD	Transportation	AAM
Magnetosphere	AAD		
Manufacturing	AAF		
Mapping	AAB		

Level 4

TASKS

Keyword	Code
Atmosphere	ABZ
Atmosphere Changes on Diurnal Scale	ACI
Atmosphere Composition	ACB
Atmosphere Composition Pressure Variation	ACG
Atmosphere Energy Distribution	ACR
Atmosphere Existence	ACA
Atmosphere Temperature Profile	ACH
Atmosphere Trends with the Solar Cycle	ACJ
Axis Determination Rotation Rate	ABJ
Charge Composition and Spectrum	ADK
Charge Composition and Spectrum in Galactic Cosmic Rays	ADL
Charge Composition and Spectrum, Quiescent and Disturbed Radiation	ADM
Charged Particle Distribution in Comet Tail	ADG
Chromosphere Structure	ACL
Comet Nuclear Composition	ABQ
Communication, Extra-terrestrial Beings	ADR
Composition General	AEC
Corona	ACO
Corona Hot Spot Mapping	ACP
Corona Structure	ACM
Corpuscular Radiation Correlation with Solar and Planetary Distribution	ADN
Deep Core Composition	ABP
Distribution of Geological Materials of Interest	ABR
Evolution of Universe	AEB
Existence of Basic Organic Molecules	ADX
Existence of Ice or Water	ABO
Existence of Panspermia	ADQ
Frequency Intensity Characteristics, EM Radiation	AEE
Geodetic Datum Tie-in	ABI
Geoid Model	ABE
Geological History Determination	ABN
Gravitational Anomalies and Geoid Model	ABE

Keyword	Code
Gross Chemical Surface Characteristics	ABL
Gross Photography	ABB
Gross Physical Surface Characteristics	ABK
Ionosphere	ACC
Ionosphere Composition	ACD
Ionosphere Location	ACE
Ionosphere Motion on Diurnal Time Scale	ACF
IR Surface Mapping	ABM
Life Form	ADO
Life Form Behavior and Habits	ADY
Life Form Classification	ADU
Life Form Distribution	ADW
Life Form Ecology	ADV
Life Form Existence, Detection of Past	ADT
Life Form Existence, Detection of Present	ADS
Life Form Existence, Determination	ADP
Lunar Red Spots	ABU
Magnetic Force Lines, Influence of Various Cycles	ADF
Magnetic Force Lines, Mapping	ADE
Magnetic Lines of Force	ADD
Magnetosphere	ACT
Magnetosphere, Existence	ACW

Keyword	Code
Magnetosphere, Gross Strength and Orientation	ACU
Magnetosphere, Interface with Solar Wind	ACV
Mass Determination	ABD
Outgassing	ABT
Photographic Mapping	ABC
Photography, General	ABA
Planetary Composition, Other Systems	ADH
Presence of Other Solar Systems	ADJ
Radiation Belt Dynamics	ADA
Radiation Belt Mapping	ADB
Radiation Belts	ACY
Radiation Belts, Correlation with Other Geophysical Phenomena	ADC
Radiation Belts, Gross Shape and Constituent Characteristics	ACZ
Radii Determination	ABF
Radii, Equatorial	ABG
Radii, Polar and Equatorial	ABG
Radio Frequency Radiation	ACQ
Radio Source in Sky Mapping	ADI
Radius, Mean	ABH
Solar Abundance of Chemical Elements	ABY
Solar Flare Mechanism	ABW
Solar Gravitation Mechanism	ABV

Keyword	Code
Solar Local Magnetic Field Mechanism	ABX
Solar Temperature Gradient	ACN
Spectroscopic Astronomy	AED
Stellar Radiation	AEF
Study Limits of Universe	AEA
Surface Bearing Strength	AEA
Surface Characteristics	ADZ
Surface Erosion Processes	ABS
Surface Magnetic Anomalies	ACS

Level 5

CONCEPTS

Keyword	Code	Keyword	Code
Asteroid	AGW	Mars and Satellites	AGQ
Astronomy, Optical	AGO	Mercury	AGX
Astronomy, Radio	AGO	Meteorological Satellite	AGG
Base, Surface	AGK	Navigation Satellite	AGL
Comet	AGV	Orbiter	AGD
Communications Satellite	AGF	Saturn and Satellites	AGS
Deep Space	AGJ	Scientific Research	AGN
Flyby	AGC	Solar Oriented	AGI
Geodesy Oriented	AGH	Space Station	AGR
Jupiter and Satellites	AGT	Technology Test Satellite	AGM
Lander	AGE	Unmanned	AGB
Lunar	AGU	Venus	AGP
Manned	AGA		

Level 6

SYSTEMS

Keyword	Code
Booster	AJC
Booster, Manned Reusable	AJP
Booster, Orbital	AJD
Cargo Vehicle	AJQ
Command and Re-entry Module	AJH
Extra-vehicular Activity Unit	AJE
Flying Vehicle, Lunar	AJX
Fuel Regeneration	AKB
Ground Support Facility	AJB
Lander	AJL
Lander/Rover	AJG
Libration Point Communications Satellite	AJZ
Logistics Vehicle	AJM
Logistics Vehicle, Expendable	AJN
Logistics Vehicle, Manned Reusable	AJO

Keyword	Code
Observatory, Optical Astronomy	AJY
Orbital Service Module	AKC
Power Plant	AJU
Power Plant, Nuclear	AJW
Power Plant, Portable	AJV
Probe	AJI
Probe, Planet	AJJ
Probe, Precursor	AJK
Radio Telescope	AKA
Rover	AJF
Shelter	AJT
Shelter, Lunar	AJR
Shelter, Maintenance	AJS
Space Station	AJA
Spacecraft	AJA
Telescope Gondola	AJA

Level 7

SUBSYSTEMS

Keyword	Code	Keyword	Code
Auxiliary Power	ALA	Guidance and Navigation	ALG
Checkout and Maintenance	ALM	Life Support	ALH
Communications	ALC	Propulsion	ALP
Data Processing	ALD	Simulation and Training	ALT
Detection, Discrimination and Tracking	ALN	Stability and Control	ALS
Display	ALY	Task Instrumentation	ALI
Escape and Recovery	ALE	Vehicle	ALV

Level 9

CONFIGURATION

Keyword	Code
Acceleration Sensor	ANL
Adaptive Flight Control	AOY
Aerodynamic Control	ART
Aerodynamic Surface	APA
Airborne Oscillator	APK
Airbreathing Turbojet	AQM
Altimeter, Radar	ARC
Amplifiers, Noise	ANY
Analog Integrator	AMF
Analog to Digital Conversion (A/D)	AMG
ANFPS-16	AMZ
Antenna Boom	ANZ
Antennas	ANX
Apollo CSM Type	BVO
Assembly Training	ARO
Atmosphere Breathing	AOD
Atmosphere Re-entry Body	APX
Atomic Clock	ANB
Attitude Gyro	AOS
Automatic Checkout	APE
Battery	AMD
Boom, Antenna	ANZ
Breathing Atmosphere	AOD
Camera	ANV
Chemical Rocket	AQK
Chemical Rocket, High Energy	AQX
Chemical Rocket, Solid	AQJ
Clock, Atomic	ANB
Closed Ecological System, Botanical Food and Oxygen	AOI
Closed Spacecraft Structure	APY
Cold Gas Jet	AOP
Computer, Digital	AMQ
Control Moment Gyro	AOS
Core Memory Data Storage	AMO
Countdown Electronics	AQY
Cryogenic Fuel Rocket	AQP
Cylinder Spacecraft	AQA
Damper	AOX
Data Storage, Core Memory	AMO
Data Storage, Digital Memory	AMS
Data Storage, Photographic Film	AMC

Keyword	Code
Data Storage, Tape	AMT
Digital Computer	AMQ
Digital Memory Data Storage	AMS
Digital Processor, Small	AMP
Direction Finder, Radio	AOL
Doppler Radar Guidance	ANK
DSIF	ANF
Dynamic Conversion	BVX
Electric Motor	AQS
Electric Propulsion	AQR
Electric Propulsion	AOT
Electromechanical Drive	AON
Encoder, Video	AMR
Engine, Nuclear	AQH
Engine, Piston	AQT
Engine, Turbine	AQU
Environmental Measurement Sensors	ANS
Escape Pod	AMX
Failure Monitoring	APC
Fault Isolation	APD
Flight Control, Adaptive	AOY
Food	AOE
Frequency Standard, Space Rated	BVT
Fuel Cell	AMA
Fuel Regeneration Unit Structure	ARL

Keyword	Code
Gaseous Core Nuclear Engine	AQG
Gimbaled Engines	AOU
Gravity Gradient	AOK
Guidance, Earth Command	ANN
Guidance, Inertial	ANE
Guidance, IR	ANQ
Guidance, Laser	ANM
Guidance, Radar	ANJ
Guidance, Radio	ANI
Guidance, TV	ANG
Guidance, Visual	ANH
Guidance, Visual	ANC
Gyro	AOS
Gyro, Control Moment	AOS
Gyro, Rate	AOS
Gyrocompassing	AOW
Heading Reference	BVM
Heat Exchanger	AMV
Heat Exchanger, Nuclear Fission	AQW
High Energy Chemical Rocket	AQX
High Resolution IR	BVR
High Resolution TV	BVQ
Hollow Sphere	AOO
Horizon Scanner	ANO
Humidity (TPH)	AOF

Keyword	Code
Hypergolic Reaction Jet	AOP
Hypergolic Rocket	AOZ
H2 Scramjet	AQV
ILS Type Terminal Guidance	BVP
Inert Gas Atmosphere	BVU
Inertial Guidance	ANE
Inertial Wheel	ARY
Inflight Skill Retention	ARN
Instruments	ARE
Instruments, Standard Planetary Package	AQZ
Integral Sensors	APB
Interferometer Receiver, Phased Array	BVS
IR Guidance	ANQ
IR Tracker	AOM
Isotope Power Source	AMJ
Isotope/Thermoelectric Power Supply	AMK
Large Mariner Type Vehicle	BVD
Laser Guidance	ANM
LF/MF Transceiver	ARJ
Liquid Rocket	AQL
Liquid Rocket, Storable	AQI
Living Quarters	AQC
Logistics Vehicle Structure	AQE

Keyword	Code
Maneuvering Re-entry Body	APZ
Mariner Type Vehicle, Large	BVD
Medical/Psycho	AOG
Meteorological Sensors	AOC
Motor Electric	AQS
Noise Amplifiers	ANT
Nuclear Engine, Gaseous Core	AQG
Nuclear Engine, Solid Core	AQF
Nuclear Fission Heat Exchanger	AQW
Nuclear Fission Reactor	AMH
Nuclear Power Plant Structure	BVY
Nuclear Rocket	AQH
Open Frame Structure	APW
Open One-man Space Vehicle	BVZ
Open Two-man Vehicle	ARI
Optics	ANR
Oscillator, Airborne	APK
Parachute	BWB
Photo Scanner	AMR
Photographic Film Data Storage	AMC
Photographic Onboard Processor	ANP
Photography	AND

Keyword	Code
Pioneer-type Spacecraft	ARD
Piston Engine	AQT
Planet Tracker	ARB
Power Conditioners	AMW
Power Conditioners	AML
Pressure (TPH)	AOF
Propulsion, Electric	AQR
Propulsion, Electric	AOT
Radar Altimeter	ARC
Radar Guidance	ANJ
Radar, Scanning	BWA
Radio Direction Finder	AOL
Radio Guidance	ANI
Radio Telescope	BVV
Radiometers	ANT
Rate Gyros	AOS
Re-entry Body, Atmosphere	APX
Re-entry Body, Maneuvering	APZ
Re-entry Training	ARM
Reaction Jet	AOP
Reaction Jet, Cold Gas	AOP
Reaction Jet, Hypergolic	AOP
Reaction Jet, Storable Liquid	AOP
Reaction Jet, Vapor	AOP
Reaction Wheel	AOQ
Recorder, Tape	AMN
Rocket, Cryogenic Fuel	AQP
Rocket, Hypergolic	AQO

Keyword	Code
Rocket, Liquid	AQL
Rocket, Solid Chemical	AQJ
Rocket, Storable Liquid	AQI
Running Gear, Extendable	BWC
Scanner, Horizon	ANO
Scanner, Photo	AMR
Scramjet, H2	AQV
Sensors, Acceleration	ANL
Sensors, Environmental Measurement	ANS
Sensors, Integral	APB
Sensors, Meteorological	AOC
Sensors, UV	ANU
Servo	AOJ
SHF Transceiver	APH
SHF Transmitter	APL
SHF/UHF Transceiver	APS
Solar Cells	AMB
Solar Dynamic Power Source	AMI
Solar Sail	ARG
Solid Chemical Rocket	AQJ
Solid Core Nuclear Reactor	AQF
Spacecraft, Cylinder	AQA
Spacecraft, Pioneer-type	ARD
Spectrometers	ANW
Standard Planetary Instrument Package	AQZ
Star Tracker	ANA

Keyword	Code
Start/Prime Vehicle	AQN
Storable Liquid Reaction Jet	AOP
Storable Liquid Rocket	AQI
Structure, Closed Spacecraft	APY
Structure, Logistic Vehicle	AQE
Structure, Open Frame	APW
Sublimation Jets	ARW
Switching, Automatic	APG
Tape Data Storage	AMT
Tape Recorder	AMN
Telescope	AOA
Telescope Mounting Structure	BVN
Temperature, Pressure, and Humidity	AOF
Thermionic Conversion	BVW
Thermoelectric Control Loop	ARA
Thermoelectric Converter	AMM
Thermoelectric Thruster	AOV
Thermoplastic Color Photography	ARU
Thrust Vector Control	AOU
Torquer	AOB
Tracker, Planet	ARB
Tracker, Star	ANA
Tracking Station	AMY
Trailer Mount	AQD
Transceiver, Laser	ARH
Transceiver, LF/MF	ARJ

Keyword	Code
Transceiver, SHF	APH
Transceiver, SHF/UHF	APS
Transceiver, UHF	APR
Transceiver, UHF/VHF	APF
Transceiver, VHF FM	APM
Transceiver, VHF TV	APN
Transmitter, SHF	APL
Transmitter, UHF/VHF	API
Turbine Engine	AQU
Turbojet, Airbreathing	AQM
UHF Transceiver	APR
UHF/SHF Transceiver	APS
UHF/VHF Transceiver	APF
UHF/VHF Transmitter	API
UV Sensors	ANU
Vapor Reaction Jet	AOP
Variable Geometry Wing	AQB
Vehicle, Open Two Man	ARI
Vehicle, Start/Prime	AQN
VHF FM Transceiver	APM
VHF TV Transceiver	APN
Video Encoder	AMR
Visual Guidance	ANH
Visual Guidance	ANC
Water	AOH
Working Space	ARK

Level 10 (*)

TECHNOLOGY DEFICIENCIES

Keyword	Code
Abrasion, Solar Cells	BDX
Abrasion, Turbine Blades	CAI
Accuracy	AZZ
Accuracy, Angle	AWZ
Accuracy, Angular Position Sensing	AXY
Accuracy, Attitude, Gravity Gradient	AYA
Accuracy, Horizon Scanner	AXU
Accuracy, Instrumentation	BHF
Accuracy, Magnetic Torquing	AXW
Accuracy, Pointing	BBT
Accuracy, Refraction Correction	AXA
Accuracy, Tracking	AXB
Accuracy, Velocity	AZA
Acquisition and Vectoring	AYZ
Aerodynamic Configuration	AVO
Antenna Deployment	AWK
Antenna Directivity	AVY
Antenna Gain	AWM
Antenna Pointing	AVZ
Antenna Size	AWL
Arcing in Vacuum	BDZ
Atmosphere Circulation and Cycling	BGY
Atmosphere Reclamation	AUU
Attitude Resolution, Hypergolic Reaction Jets	AXJ
Attitude Stability, Hypergolic Reaction Jets	AXQ
Attitude, Interference, Lossy Spring	AYC
Automatic Beam Coupling	AZB
Automatic Erection and Alignment	AWY
Bacteria Destruction, Recycled Water	BCP
Bacteria Destruction, Tanked Water	BCJ
Bearings, Solar Panels	BEJ
Biological Gas and Odor Productions	BHB
Calibration Standards	BHG
Cargo Transfer Technique	AUK
Charge Neutralization	BFE
Choice of Frequency	BFU

Keyword	Code
CO_2 & CO Monitor, Alarm, and Removal, Nitrogen/ Oxygen	BBY
Coding	AWC
Comfort Factors	BGX
Communications Efficiency	AWN
Complete Expulsion, Cryogenics	AUM
Contaminant Alarm, Monitor and Removal	BDO
Contaminant Detection	BDM
Contaminant Detection, Closed Ecolcgical System	BCF
Contaminant Detection, Inert Gas	BCA
Contaminant Detection, Nitrogen/Oxygen	BBV
Control Moment Generator	AUD
Conversion Efficiency	BET
Cooldown and Restart	ASZ
Coriolis Effect	BDE
Correlation of Return with Atmospheric Characteristics	BFV
Corrosive Fuel Handling	ATH
Cost, Grenades	BBO
Cost, Lower	AWO
Cost, Rocket	ASD
CO_2 & CO Monitor and Alarm, Closed Ecological System	BCE

Keyword	Code
Crevice Avoidance	ATS
Crew Mix	ASB
Cryogenic Frosting	AUL
Cryogenic Storage	ASR
Cryogenic Transfer	AUJ
Cutoff and Restart Capability	ATD
Cutoff Precision	ATE
Cutoff Precision	ASL
Damping, Gravity Gradient	AYM
Data Compression	BAX
Data Compression, Digital Computer	BAI
Data Compression, Digital Processor	BAJ
Dead Zone	AXI
Deboost and Ascent Calculation	AZG
Deployment, Solar Cells	BEK
Depressurization for EVA	BVE
Diagnosis and Treatment of Health	BDC
Docking Shock	AVC
Doppler Compensation	AWV
Earth Field Compensation	AYB
Ease of Emplacement	AUO
Efficiency, Power Lines	BEA

Keyword	Code
Electrical Discharge Danger, Low Pressure	BDR
Electrical Noise	BDY
Electronics	BHD
Environmental Control	AUT
Fabrication Precision	BBM
Failure Alarm	AVX
Fast Acting Repressurization	BCW
Fault Isolation	AVP
Feasibility	BFG
Fire Extinguisher, Non-Toxic	BCX
Frosting at Leak Areas	AUV
Fuel Consumption	AYN
Fuel Handling	AUH
Fuel Supply Limitation	ATJ
High Load Efficiency	CAG
High Strength Lightweight Structure	ATO
High Temperature Material	ASW
High Temperature Operation	BAN
High Velocity Re-entry	AVK
High Voltage Power Source	BFD
High-load Efficiency	BER
Higher Order Control Techniques	AYE
Horizon Definition	AYF

Keyword	Code
Hypersonic Release, Second Stage	ASG
Impulse Accuracy	ATG
Inflight Test, Electric Propulsion	ASQ
Interference with Observation	AWT
Ion Removal and PH Control	BDK
Ion Removal and PH Control, Fuel Cell Water	BCL
Ion Removal and PH Control, Recycled Water	BCN
Ion Removal and PH Control, Tanked Water	BCI
Isotope Resources	BEC
Landing Shock	AUA
Large Vehicle Assembly Operation	AVH
Laser Acquisition	BGD
Laser Tracking	BGC
Leak Detection	AUW
Leak Detection and Alarm	BDP
Leak Detection, Closed Ecological System	BCD
Leak Detection, Inert Gas	BBZ
Leak Detection, Nitrogen/Oxygen	BBX
Leakage	AUR
Life Support System Integration	BCU

Keyword	Code
Life Support System Integration	BGH
Limiting Torquing Rate	AXX
Local Oscillator	BBN
Low Signal/Noise Ratio	AWU
Maintainability	BAK
Malfunction Detection	AVW
Material Degradation	AVI
Measurement Technique	BHI
Memory Density	BAW
Memory Density, Digital Computer	BAF
Memory Density, Digital Processor	BAG
Memory Density, Tape Recorder	BAH
Meteoric Protection	ATZ
Minimum Impulse	BHE
Monitoring and Switching	AVS
Monotony, Stored Food	BCQ
Morale	BDA
Multiple Access	AWH
Noise, Video Encoder	BAS
Non-linear Performance, Thermoelectric Thrusters	AXG
Nuclear Shielding	ASX
Nutrient/Bulk Ratio	BGZ

Keyword	Code
Odor and Contaminant Removal	BDN
Odor and Contaminant Removal, Closed Ecological System	BCG
Odor and Contaminant Removal, Inert Gas	BDI
Odor and Contaminant Removal, Nitrogen/Oxygen	BBW
Operating Life, Electrical Propulsion	ASP
Optical Window Degradation	AVE
Orbital Assembly, Grappling of Large Masses	AUY
Oscillator Stability	AWR
Over-the-Horizon Radio Propagation	AWX
Oxygen Removal from Helium Atmosphere	BCC
Performance	BVH
Portability	AXD
Portal Air Loss	AUS
Portal Reaction Thrust	AVJ
Portals, EVA	AUZ
Portals, Inflatable Structure	AUX
Precise Knowledge of Star Position	BVJ
Precision Angle Measurement	AYV
Preparation and Reconstitution, Crumbs, Outgassing	BHA

Keyword	Code
Preservation, Food	BCS
Pressure Control	BDQ
Psychological Implication	BDJ
Psychological Implication, Recycled Water	BCM
Psychological Implication, Tanked Water	BCK
R&D Required	ARZ
R&D Required, Approach TV	AZO
R&D Required, Botanical Sources	BGV
R&D Required, Boundary Layer Cooling	ASH
R&D Required, Camera Platform	BAZ
R&D Required, Countdown Electronics	BFI
R&D Required, Countdown Electronics	BAU
R&D Required, Digital Computer	BAM
R&D Required, Digital Electronics	BBH
R&D Required, Doppler Radar	AZL
R&D Required, Electric Propulsion	BHC
R&D Required, Escape Pod	BGM
R&D Required, Film	BGP
R&D Required, Film On-board Processing	BAT

Keyword	Code
R&D Required, Frequency Standard	BFK
R&D Required, Fuel Regeneration Process	AUP
R&D Required, Heading Reference	BVK
R&D Required, High Energy Upper Stage	BFH
R&D Required, High Resolution IR	BBB
R&D Required, High Resolution TV	BBA
R&D Required, High Speed Readout	BAQ
R&D Required, Hydrogen Fueled Scramjet	CAF
R&D Required, Hypergolic Fuel Piston Engine	CAA
R&D Required, Image Intensifier	BBC
R&D Required, Inertial	AZH
R&D Required, Inter-ferometer	BBS
R&D Required, Inter-ferometer Techniques	AWJ
R&D Required, IR Sensor	BBE
R&D Required, Laser	AZQ
R&D Required, Liquid Rocket	ATI
R&D Required, Maneuvering Re-entry Vehicle	BFN
R&D Required, Microwave Sensors	BAY

Keyword	Code
R&D Required, Nuclear Rocket	ASY
R&D Required, Open Two-Man Lunar Flying Vehicle	ATP
R&D Required, Parachute Recovery	BFJ
R&D Required, Pattern Recognition	BAL
R&D Required, Phased Array	AWI
R&D Required, Planet Tracker	AZK
R&D Required, Radar	AZR
R&D Required, Radar Altimeter	BFT
R&D Required, Radiative Re-entry	AUF
R&D Required, Raster Motion	CAD
R&D Required, Scanning Radar	BVL
R&D Required, Spectrometer	BBG
R&D Required, Star Tracker	AYS
R&D Required, Sun Tracker	CAC
R&D Required, Thermoelectric Control Loop	BFL
R&D Required, Thermoelectric Conversion	BFO
R&D Required, Thermoelectric Thruster	ZXF
R&D Required, Thermoelectric Thrusters	AXF
R&D Required, Thermoplastic Color Photography	BGQ
R&D Required, Thrust Vector Control	AXO
R&D Required, Turbine Engine	CAB
R&D Required, TV Camera	BBD
R&D Required, UV Sensor	BBF
R&D Required, Variable Geometry Wing	ATN
R&D Required, Variable Speed Tape Recorder	BGO
R&D Required, Vibration Noise, Reaction Wheels	CAE
Radiation Alteration of Memory	BBU
Radiation Damage, Film	BAP
Radiation Damage, Semiconductor	BED
Radiation Damage, Thermoelectric	BFW
Radiation Protection	AVD
Re-entry G Physiology	BDF
Re-entry Heating	AVN
Realism of Zero G Work	ASA
Reclamation of Breathing Oxygen	BGU
Reclamation of Breathing Oxygen	BCB
Recycle Limited, Battery	BEQ
Reduction in Natural Immunity	BGT

Keyword	Code
Redundancy	ASI
Reliability	ARR
Reliability, Accelerometer	AZI
Reliability, After Long Storage	ASM
Reliability, After Shutdown	ASV
Reliability, Antenna Pointing	AWQ
Reliability, Battery	BEW
Reliability, Checkout and Maintenance Equipment	AVQ
Reliability, Cold Gas Jet	AYO
Reliability, Communication Equipment	AWW
Reliability, Countdown Electronics	BAE
Reliability, Countdown Electronics	BFM
Reliability, Digital Computer	AZY
Reliability, Digital Processor	BAA
Reliability, Doppler Radar	AZM
Reliability, Electro-mechanical	AYP
Reliability, Fuel Cell	BEY
Reliability, Gyro	AXN
Reliability, Horizon Scanner	AXM
Reliability, Hypergolic Reaction Jet	AXL
Reliability, Inertial Shutdown	AZE
Reliability, Inertial System	AZC
Reliability, Inertial, Shut-down	AYJ

Keyword	Code
Reliability, Instrument Package	BHH
Reliability, Laser	AZP
Reliability, Mechanical	ASJ
Reliability, Mechanical, Rotating Structure	AVA
Reliability, Mechanical, Running Gear	AUB
Reliability, Nuclear Reactor	BDT
Reliability, Planet Tracker	AZJ
Reliability, Power Conditioners	BDV
Reliability, Pumps	AUQ
Reliability, Radar	AZT
Reliability, Radar Altimeter	AZN
Reliability, Radio Direction Finder	CAH
Reliability, Restart	ATB
Reliability, Rocket	ATM
Reliability, Servo	AYR
Reliability, Shutdown, Fuel Cell	BEV
Reliability, Solar Cells	BES
Reliability, Standby	AWP
Reliability, Standby	ATK
Reliability, Star Tracker	AXS
Reliability, Tape Recorder	BAB
Reliability, Tape Recorder, Variable Speed	BAC
Reliability, Temperature Pressure, Humidity	BCY

Keyword	Code
Reliability, Thermoelectric Thruster	AXH
Reliability, Thrust Vector Control	AXR
Reliability, Trailer Structure	AUI
Reliability, Transmitter	AWG
Reliability, Video Encoder	BAD
Response Time, Meteorological Sensors	BBR
Response, Shutter	AXC
Restart and Alignment in Orbit	AZD
Restart Capability	ATC
Rotary Bearings	AYL
Sanitation	BDB
Selection and Development, Closed Ecological System	BCT
Self-Destruction Rocket	ASE
Self-Orientation, Fuel Cell	BEU
Service Life, Fuel Cell	BEO
Servo Null and Threshold	AXZ
Simplification	AVV
Size and Weight, Grenades	BBP
Size, Electromechanical Drive	AYI
Size, Meteorological Sensors	BBQ
Size, Radio Direction Finder	AYG
Skill Retention	ASC
Software Flexibility	BAO

Keyword	Code
Solar and Cosmic Noise	AWA
Spaceborne Packaging	BGR
Spares, Weight and Interchangeability	AVT
Specific Area, Solar Cells	BEB
Specific Cost	BEP
Specific Cost, Battery	BEL
Specific Cost, Fuel Cell	BEM
Specific Cost, Solar Cells	BEN
Specific Energy	BEF
Specific Impulse	AST
Specific Power	BEE
Specific Power, Fuel Cell	BEI
Specific Power, Nuclear Reactor	BEX
Specific Power, Solar Cell	BEG
Stability Dynamic Range	AYK
Star Identification	AXT
Startup	ATA
Steerable Running Gear	ATR
Sterilization and Back Contamination	ATW
Sterilization, Instruments	BHJ
Structural Integrity	AUN
Surface G Physiology	BDG
Surgical Implant of Biomed Sensors	BDD
Technical Data Access	AVR
Telescope Gimbaling	BBJ

Keyword	Code
Temperature	BDS
Temperature Control	BFB
Temperature Control	BAV
Temperature Distortion	AYW
Temperature Limited Efficiency	BDU
Temperature Limited Efficiency	BFA
Thermal and Radiation Protection	BFX
Thermal Body Flexure	BVI
Thermal Effects on Large Lens	BBK
Threshold Rate Gyro	AXV
Throttleability	ATL
Thrust Vectoring	ATF
Thrust/Weight Ratio	BFF
Toxic Contaminant Removal	BGW
Trace Contaminants	BDL
Trace Contaminants, Closed Ecological System	BCV
Trace Contaminants, Recycled Water	BCO
Tracking Accuracy	AZX
Tracking Accuracy, Laser	AZU
Tracking Accuracy, Radar	AZS
Transmitter Efficiency	AWD
Transmitter Life	AWE
Transmitter Power	AWB
Transmitter Size	AWF

Keyword	Code
Transport Efficiency	BGA
Transportation Vibration and Shock	BBI
Uncertainty in Ephemeris	AYX
Uncertainty in Lunar Terrain	ATV
Uncertainty in Mass	AYZ
Uncertainty, Mars Atmosphere	ATY
Uncertainty, Mars Surface	AVB
Uncertainty, Venus Atmosphere	ATX
Uncertainty, Venus Surface	ASF
Vehicle Stability	BGN
Vibration Suppression	AYD
Waste Disposal, Food	BCR
Waste Heat Rejection	BCZ
Waste Heat Rejection	AUG
Waste Removal	AVF
Wearout	BDW
Wearout, Reaction Wheel	AXK
Weight	AVL
Weight, Ablative	AUE
Weight, Checkout and Maintenance Equipment	AXE
Weight, Electric Drive	ASK
Weight, Electromechanical Drive	AYH

Keyword	Code
Weight, Escape Pod	BGL
Weight, Ground Beacon Seeker	AYT
Weight, Hollow Sphere	AYQ
Weight, Inertial	AZF
Weight, Open Two-Man Lunar Flying Vehicle	ATQ
Weight, Rover	ATU
Weight, Running Gear	AUC
Weight, Structural	AVM
Weight, Tape Recorder, Variable Speed	BAR
Weight, Telescope Mirror	BBL
Wideband Modulation	AWS
Zero G Physiology	BDH
Zero G Work, Tools	AVU

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Appendix C

RELEVANCE ASSIGNMENT

After the selection of judges and their familiarization with the relevance manual, we are ready to assign relevance. The individuals who assigned relevance for the Series IA data presented under the contract are listed in Table C-1. There are two kinds of ballots: the PATTERN tree (relevance) ballots and the experiment ballots.

C.1 RELEVANCE ASSIGNMENTS

The values are recorded on a computer-printed ballot, an example of which is reproduced in Figure C-1. Pertinent parts of the ballot are labeled. Point A indicates the ascending, unique ballot number (00062), the series (IA), and the date the ballot was printed (4 November 1965). The series designator represents a data sophistication designator. Under the present contract data delivered is titled Series IA. Any revision of output of interpretation of data stored in the computer or in the documentation will be given a separate letter designator such as Series IB, IC, etc. Where actual input data is changed, such as balloted relevance, addition of a concept, etc., the numerical series will be advanced, for example, Series IIA. A central file should be maintained by the appropriate NASA authority to regulate changes in PATTERN data. It is suggested that a master file of computer data tape be maintained for each series change. This would involve duplicating the tape before modification is made to it and would allow rapid reference to any phase of the data. See Section 4.0, Updating and Data Management, for further details.

Point B indicates the voter code. The judge should print his initials in the space provided. If he has no middle initial, the judge should use the first two boxes leaving the last blank. For example, Richard Emmet Lucy |R|E|L| or Bernard Yaged |B|Y| |. The format for this code is maintained throughout the tree with one important exception. When assigning relevance to the ballots for the field of interest (three) level to the concept (five) level, the first character must be a "Z" followed by the first and last initials. For example, determining the relevance of concepts to Lunar Composition, the code for Richard Emmet Lucy would be |Z|R|L| or for Bernard Yaged |Z|B|Y| . "Z" is an allowable first

Table C-1

RELEVANCE ASSIGNERS

Code	Name	Title	Location
JGB	J. G. Ballinger	Principal Research Scientist	S&RD, Minneapolis
REB	R. E. Brady	Staff Engineer	Aero Florida
CWB	C. W. Benfield	Staff Engineer	Aero Florida
CED	C. E. Durham	Principal Staff Engineer	Aero Florida
RED	R. E. Dobrzynski	Project Engineer	Aero Minneapolis
RLD	R. L. Day	Staff Engineer	Aero Florida
JLK	J. L. Kirk	Planning Engineer	MSSD Washington
EAM	E. A. Montross	Staff Engineer	Aero Florida
BTM	B. T. McClure	Research Section Chief	Hopkins Research Ctr., Minneapolis
JEO	J. E. O'Neill	Project Engineer	Aero Minneapolis
JRP	J. R. Plaster	Staff Engineer	Aero Florida
RHP	R. H. Parvin	Staff Engineer	Aero Florida
WCS	W. C. Sproull	Planning Staff Engineer	MSSD Washington
JTV	J. T. VanMeter	Planning Staff Engineer	MSSD Washington
NJV	N. S. VanPeer	Principal Development Engineer	Aero Minneapolis

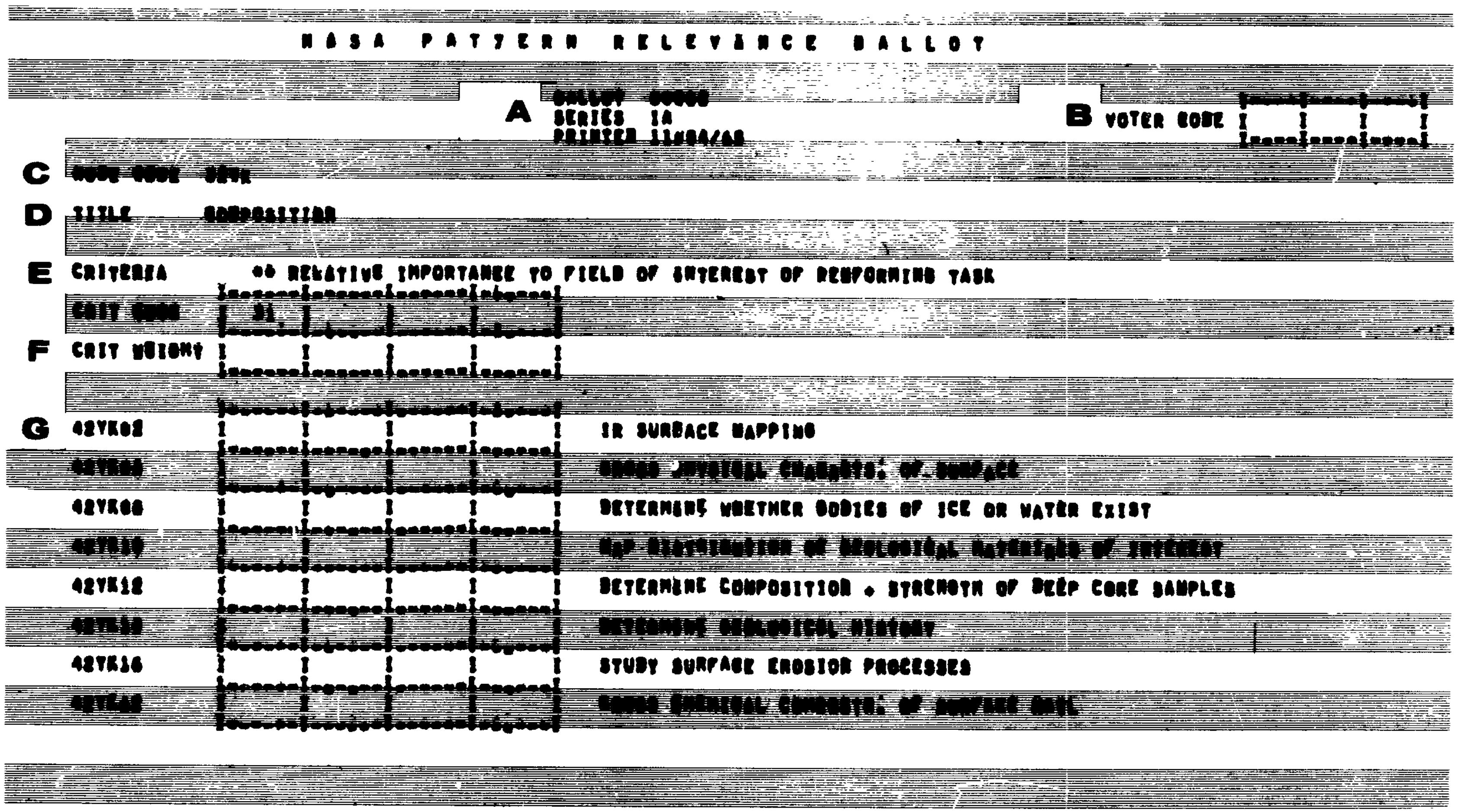

FIGURE C-1. NASA PATTERN RELEVANCE BALLOT character only on these ballots. Care should be exercised to maintain uniqueness of these indicators.

Point C indicated the node code. This is the designator for the point on the tree at which relevance is being assigned. Point D indicates the node title.

Point E indicates the criteria titles. In this case there is only one criterion. However, there may be up to four. Each title will be printed beginning with a double asterisk over the column to which it applies.

Point F indicates the criteria weight row. This is always the first assignment on the ballot. In cases (as the example) where there is a single criterion, voters should print 100 in the matrix cell at the appropriate location. Otherwise, print the assigned values for the criteria.

In the PATTERN relevance assignment procedure, judges rank the element set on a scale of 0 to 100. Input to the computer and output from it, 1.0 is printed as 100. There are two means of assigning relevance. Judges may scale their votes to sum to 1.0 (100 on the ballot) or leave them unsealed, allowing the computer to scale them. Using the first method, the criteria row must sum to 1.0 (100 on the ballot). For example, criterion 1 = 0.7 and criterion 2 = 0.3. Also the columns under each criterion must sum to 1.0. For example, under criterion 1, element 1 = 0.5, element 2 = 0.25, and element 3 = 0.25. The values are assigned according to magnitude of the differences in relevance. Using the latter method, the judge selects the most relevant element and gives it a reference number (usually 100). He then surveys the rest of the containing four elements (A, B, C, D), element B is the most relevant and is assigned 100. Element D is half as relevant as B and has value of 50. Element C is one-tenth as relevant as B and one-fifth as relevant as D, having relevance of 10. Element A is twice as relevant as C, having relevance of 20. Final ranking is B:100, D:50, A:20, and C:10. After each judge marks his ballot, there should be a discussion period concerning differences in the relative ranking of each individual to ensure that all relevant facts were considered and that all judgments are based on the same set of facts. For example, the judge in the above example determined a ratio of 2 to 1 for B to D. Another may have voted a 10 to 1 ratio for B to D. The reasons for each assignment would be discussed with an opportunity provided to modify the choice. This process is not designed to cause assignments to converge, but that is the general result. The assignment procedure is the same for criteria as for elements.

The computer program takes the information on the final ballot and scales it to the sum of 1. 0 before calculating the relevance as detailed in Appendix A, Computer Program.

Point G indicates the elements to be judged. They are assigned down the criteria column, not across the row. Additional elements may be added, but care should be exercised to assign the correct ode number. Deletion of elements is accomplished by lining out the selected column.

One advantage of PATTERN is now readily observable, that of consideration of a small but complete set of elements at each selection. This allows detail decisions on macroscopic items. The number of elements assigned at a time rarely exceeds ten and, because of the computer program limitation, may not exceed twenty.

C. 2 EXPERIMENT RELEVANCE

The second type of ballot is the experiment ballot, an example of which is reproduced in Figure C-2. Pertinent parts are labeled.

Point A indicates the unique ballot number (52-7), the series (1A), and the date the ballot was printed (9 December 1965). The remarks applied to relevance ballots are applicable here.

Point B indicates the voter code, which is again the initials of the judge.

Point C indicates the experiment code and title and Point D shows the node code and title.

Point E indicates the box for the experiment relevance assignment.

Point F indicates the scale on which to rank the experiment. Judgment on the experiments is similar to the relevance assignment. It uses the same criteria as in relevance assignment. The judges place the experiment somewhere on the scale provided by the listing of elements and values at Point F. The vote is from 0 to 100. The scale at Point F is the un-normalized average value for that level.

Experiments are ranked at both the field of interest (three) and alternate configuration (nine) levels. All remarks apply equally to both levels.

```
                                                                                   1265-358B

                    N A S A   P A T T E R N   E X P E R I M E N T   B A L L O T

                                 BALLOT    52 - 7                      I----I----I----I
                               A SERIES    IA              B VOTER CODE I    I    I    I
                                 PRINTED 12/09/65                      I----I----I----I

C EXPERIMENT:  9181    TITLE:  3B13TOXICOLOGICAL STUDIES OF RESPIRATORY GASES

                                                                              I-----I
D NODE CODE :  9V002SH11       NITROGEN/OXYGEN ATMOSPHERE            E VOTE   I     I
                                                                              I-----I

   F ELEMENT CODE: *V002SH114      ODOR&CONTAMINANT REMOVAL,NITROGEN/OXYGEN        100
     ELEMENT CODE: *V002SH113      CONTAMINANT DETECTION,NITROGEN/OXYGEN            80
     ELEMENT CODE: *V002SH111      LEAK DETECTION&ALARM,NITROGEN/OXYGEN             77
     ELEMENT CODE: *V002SH112      CO2&CO MONITOR,ALARM,REMOVAL-NITROGEN/OXYGEN     73

                                                                              I-----I
D NODE CODE :  9YF02MH11       NITROGEN/OXYGEN ATMOSPHERE            E VOTE   I     I
                                                                              I-----I

   F ELEMENT CODE: *YF02MH111      LEAK DETECTION&ALARM,NITROGEN/OXYGEN            100
     ELEMENT CODE: *YF02MH112      CO2&CO MONITOR,ALARM,REMOVAL-NITROGEN/OXYGEN     60

                                                                              I-----I
D NODE CODE :  9YF02SH11       NITROGEN/OXYGEN ATMOSPHERE            E VOTE   I     I
                                                                              I-----I

   F ELEMENT CODE: *YF02SH114      ODOR&CONTAMINANT REMOVAL,NITROGEN/OXYGEN        100
     ELEMENT CODE: *YF02SH113      CONTAMINANT DETECTION,NITROGEN/OXYGEN            80
     ELEMENT CODE: *YF02SH111      LEAK DETECTION&ALARM,NITROGEN/OXYGEN             77
     ELEMENT CODE: *YF02SH112      CO2&CO MONITOR,ALARM,REMOVAL-NITROGEN/OXYGEN     73
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FIGURE C-2. NASA PATTERN EXPERIMENT BALLOT

The ballots are generated using keywords to select the appropriate nodes at the three and nine levels. The formating is discussed in Appendix B.

The individuals who determine relevance for Series 1A experiments are listed in Table C-2.

Table C-2

EXPERIMENT RELEVANCE ASSIGNERS

Code	Name	Title	Location
CWB	C. W. Benfield	Staff Engineer	Aero Florida
RLD	R. L. Day	Staff Engineer	Aero Florida
EAM	E. A. Montross	Staff Engineer	Aero Florida
JAM	J. A. Miller	Project Engineer	Aero Minneapolis
RHP	R. H. Parvin	Staff Engineer	Aero Florida

C. 3 STATUS AND TIMING

Another important determination is that of status and timing, which is done at the same time as the relevance assignment. Status and timing are determined only at the Technological Deficiency (*) level and the Subsystem (seven) level.

The status and timing blocks are in the following format (Figure C-3).

Box	1	2	3	4	5
Status				X	
Timing	1	2	4	3	

FIGURE C-3. STATUS AND TIMING DIAGRAM

C. 3. 1 Technological Deficiency Level

An "X" shall be placed in the box that represents the status of each technology deficiency level item in meeting its subsystem requirements. The definitions for each box follow:

Box 1 Available - state of the art off-the-shelf hardware for operational use, including production time.

Box 2 Product Design - technical problems solved, feasibility demonstrated, development completed, and equipment ready for production design.

Box 3 Advanced Development - Includes all development efforts which have moved into the state of experimental fabrication for testing in realistic operating environment to determine equipment capability to solve a particular operating problem.

Box 4 Exploratory Development (Applied Research) - Includes all development efforts aimed at establishing technically feasible techniques for solving specific operating problems. Bench test and laboratory evaluation on breadboard/circuit-board hardware to determine the technical feasibility of a particular design approach is inherent in this type of effort.

Box 5 Fundamental Research - Includes all effort directed toward increased knowledge of natural phenomena and environment and efforts directed toward the solution of problems in the physical, behavioral, and social sciences.

Timing numbers are placed in each of the lower boxes to represent the years required to move to the next most advanced technology status. For example, using the box in Figure C-3, the definitions are as follow:

Technology for this subsystem is currently in Exploratory Development status (box 4).

Three years before technology reached Advanced Development status.

Four years required to move from initial product Design status to Available.

Two years required to move from initial Product Design status to Available.

One year from Available to initial Operational status. (This period includes adaptation, qualification, and checkout.)

Ten years required from present status to Operational status.

C. 3. 2 SUBSYSTEM REQUIREMENT LEVEL

The same definitions for status and timing described above shall hold true at the subsystem level. Here, however, the following rules shall apply.

The status and timing designators shall indicate the status and timing of the subsystem as paced by the earliest acceptable configuration. This means that where an alternate exists for far out technology deficiencies the shorter development alternate shall be used to indicate status and timing of the subsystem. The subsystem status and timing block should have the same designation and numbers as the farthest out technology deficiency in the earliest acceptable configuration.